SCIENCE

FRIDAY, JUNE 27, 1913

CONTENTS

The Physico-chemical Conditions of Anesthetic Action: PROFESSOR RALPH S. LILLIE 959

Psychologists as Administrators: DR. CHRISTIAN A. RUCKMICH 972

The Plant Industry Hall of the University of Nebraska 974

The Physical Laboratory of Washington and Jefferson College 975

Scientific Notes and News 975

University and Educational News 978

Discussion and Correspondence:—

The Laws of Nomenclature in Paleontology: A. C. PEALE. *Ice Caves:* PROFESSOR ARTHUR M. MILLER. *A Human Monstrosity:* L. D. PEASLEE. *The Omaha Tribe:* FRANCIS LA FLESCHE 979

Scientific Books:—

Darboux's Éloges académiques et divers: PROFESSOR R. C. ARCHIBALD. *Ridgway on Color Standards and Nomenclature:* DR. W. J. SPILLMAN. *Burnet on Microbes and Toxins:* PROFESSOR C.-E. A. WINSLOW ... 983

Special Articles:—

A Third Group of Linked Genes in Drosophila ampelophila: A. H. STURTEVANT .. 990

The North Carolina Academy of Science: DR. E. W. GUDGER 992

Societies and Academies:—

The Academy of Science of St. Louis: PROFESSOR G. O. JAMES 994

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THE PHYSICO-CHEMICAL CONDITIONS OF ANESTHETIC ACTION[1]

UNDER certain well-defined artificial conditions, as well as under some that are normal, the living system—organism, tissue or cell—becomes temporarily inactive and irresponsive to stimuli. When such an artificially induced state of inhibition is well marked and lasting it is called anesthesia, or in a somewhat more restricted sense, narcosis. This condition may last for hours or even days, but apparently not indefinitely; and when it passes off the normal vital activities and properties return unimpaired. This apparently complete *reversibility* is one of the most remarkable features of anesthesia, and distinguishes it from death—a perhaps related but characteristically irreversible change. The terms "anesthesia" and "narcosis" are somewhat differently applied, although they have the same essential significance; the former relates to any temporarily insensitive condition, however produced, while "narcosis" usually means an anesthesia produced by chemical substances. I shall use the term anesthesia throughout the present address to designate any temporary or reversible lowering or loss of the normal vital responsiveness, or of the normal automatic vital activity, under the influence of certain artificial substances or conditions. Anesthesia, as thus defined, may be exhibited by the most various organisms and cells, if not by all. It is fully as characteristic of plant cells as of animal cells, although its manifestations may be less obvious and striking

[1] Lecture given before the Chemical Society of Washington, April 11, 1913.

in the former group of organisms. In its most familiar aspect the complete organism, *e. g.*, a man, or an isolated living tissue, as a nerve or muscle, fails during anesthesia to show any response to a stimulus which normally excites it strongly. In other words, the capability of responding to stimuli—what we call "irritability"—is in anesthesia diminished or lost. When the condition passes off the normal responsiveness returns unimpaired. Thus a muscle exposed to ether vapor soon ceases to contract on stimulation; under the same conditions a nerve ceases to conduct; in motile plants like sensitive plants the characteristic osmotic motor mechanisms cease to act. Automatic activities like ameboid movement, ciliary movement, protoplasmic flowing, cell division, and growth may also be brought temporarily to a rest by anesthetics. Claude Bernard showed long ago that seedlings ceased growth in an ether-impregnated atmosphere, and resumed it when the ether was removed. Fertilized egg-cells cease to divide in the presence of an anesthetic in appropriate concentration, although they remain living and proceed with cell-division and development when the anesthetic is removed. Other less evident cell-processes, including metabolism, are similarly affected; the rate of oxidation is usually slowed during anesthesia, though there are exceptions to this rule.

It should be remembered that such decrease of the vital activity or responsiveness is not a solely artificial phenomenon. Conditions physiologically resembling anesthesia occur normally in the life of many organisms; sleep is in fact a kind of physiological regularly recurring narcosis due apparently to accumulation of certain metabolic products in the blood or tissues. Again, all irritable tissues lose their responsiveness for a brief period following excitation; this is the so-called "refractory period," which has been compared with narcosis by some physiologists. The resemblance in this case is probably superficial; but I call attention to this phenomenon in order to show once more that temporary loss of irritability may occur under normal or physiological conditions as well as under artificial. There are also noteworthy resemblances between narcosis and fatigue. Thus the degree of irritability of a tissue may vary within a wide range under normal as well as artificial conditions.

We shall first inquire under what general conditions irritable tissues undergo reversible decrease or loss of irritability. These conditions are various. One of them is cold. The living system operates within a narrow range of temperature. Most irritable tissues or cells become less responsive or lose irritability as the temperature approaches zero. In a muscle or nerve of a cold-blooded animal the ability to respond to stimulation is not necessarily decreased by a moderate reduction of temperature—in fact, slight cooling may increase the irritability of nerve; the tissue responds in the typical manner, but the *rate* of the response—as indicated by the duration of the single contraction in muscle or of the electrical variation in nerve—is always decreased, typically to a degree corresponding to the usual temperature-coefficient of chemical reaction-velocity. In the neighborhood of zero stronger stimuli becomes necessary to elicit a response, and eventually none may appear. Different organisms vary in these respects. In some animals, as tropical medusæ, irritability is abolished or greatly lowered at a temperature considerably above zero. The same is true of warm-blooded animals. On return to normal temperature irritability is restored.

Another condition producing effects resembling anesthesia is lack of oxygen. This

retards or arrests activity in many cases; *e. g.*, the nerve cells of vertebrates are very susceptible to lack of oxygen; nerve trunks, on the other hand, are relatively insusceptible. Cell-division—*e. g.*, in developing egg-cells—usually ceases if the oxygen supply is insufficient. Contractile activities are decreased or abolished. Many organisms, however, show only slight immediate effects; this is true of many Protozoa; Vorticellæ, for instance, remain contractile for some time after simple removal of oxygen from the medium, although they are at once paralyzed by anesthetics. Such facts oppose the view held by Verworn and others, that the anesthetic acts primarily on the oxidative mechanism of the cell. It is true that the rate of oxidations in active tissues is lowered during anesthesia, but this effect is rather a consequence than a cause of the lessened activity. Obviously wherever free oxygen is necessary to the normal activities of a tissue its withdrawal will arrest those activities. But the effects produced by lack of oxygen are not to be identified with anesthesia because of such incidental resemblances.

There are also a number of physical conditions that may deprive a cell temporarily of irritability. Thus mechanical shock may have this effect, which, however, is probably to be regarded as essentially a consequence of over-stimulation, causing abnormal prolongation of the refractory period.[2] The same is probably true of the insensibility produced by strong electrical currents. Under certain conditions, however, the electric current may produce effects closely resembling typical anesthesia. This occurs when a weak constant current is passed through an irritable tissue like muscle or nerve; during the flow of the current the irritability of the tissue is modified in the neighborhood of the two electrodes, being heightened at the cathode and lowered at the anode; and in this latter region the nerve may become completely insensitive to stimuli that ordinarily cause strong excitation. The inexcitable state thus produced is called "anelectrotonus"; it is in reality a form of local anesthesia, and as such has been employed for the alleviation of pain in sciatica and similar conditions. Muscle is affected in a similar manner; the frog's heart may thus be rendered locally incapable of contraction, as in the simple class-experiment familiar to all physiologists. This action of the current probably depends on its altering the electrical polarization normal to the membranes of the irritable elements—only in a direction the inverse of that causing stimulation.[3] There is much evidence that the state of polarization of the semipermeable membranes bounding the irritable elements is an important factor in determining the degree of responsiveness to stimulation; the facts of electrotonus indicate that by altering the polarization by an external current the irritability of the tissue may be changed in the direction either of increase or of decrease.

Irritability may, however, be more readily modified by the use of chemical substances than by any other means, and, as is well known, many such substances are in daily use in medical and surgical practise for procuring local or general insensibility to pain—hence the application of the name "anesthetic" to the large class of substances possessing this property. When we inquire into the chemical nature of such substances we find that anesthetic property is confined to no special class, but is ex-

[2] This apparently corresponds to the period of increased permeability and depolarization accompanying stimulation.

[3] *I. e.*, reinforcing instead of diminishing the normal or physiological polarization of the membranes.

hibited by substances of the most diverse chemical character. Acids in low concentration depress the irritability of many tissues; in some cases alkali has this effect; gases like carbon dioxide and nitrous oxide have marked anesthetic action; solutions of magnesium, calcium and strontium salts cause local anesthesia in frog's muscle and nerve; pure solutions of sugar and other indifferent non-electrolytes have similar effects; in these tissues irritability depends on the presence of certain electrolytes, especially sodium salts, in the media and returns on replacing the tissues in solutions containing these salts. But the most significant relationships are seen in the case of the large class of substances, differing widely in chemical constitution and properties, which possess in common the physical property of dissolving fats or of dissolving in fats. These substances include the majority of the anesthetics in common use, as ether, chloroform, ethyl chloride, urethane, etc. The connection between fat-dissolving power and anesthetic property was in fact early recognized—first by Bibra and Harless in 1847; and this relationship is of great physiological significance, since it indicates that the anesthetic is selective in its action on the cell constituents, and produces its effects by changing the state of fatty or fat-like substances in protoplasm. It indicates further that the state of these substances determines the degree of irritability of the cell. All cells, so far as known, contain such substances; they are the so-called "lipoids" which include lecithin and cholesterin, and various other ether-soluble compounds of usually complex constitution. Historically these substances were first grouped into a class simply on account of their fat-like solubilities, so that they form, chemically speaking, a somewhat heterogeneous group, some members of which, as cholesterin, are not fats in any sense. Others, as lecithin, are more closely related to the fats proper. They appear to be invariable constituents of protoplasm—a fact which in itself is not surprising in view of the amino-acid constitution of proteins: since proteins are largely derivatives or condensation-complexes of amino-fatty acids, fat-like substances might be expected to appear in cells during metabolism. It is clear, however, that these substances are not mere by-products of protein metabolism, or reserve material like fats, but play a fundamental rôle in cell-processes; the profound physiological effects produced by all lipoid-solvent substances are a sufficient proof of this, although regarding the precise nature of this rôle we know little as yet. In some intimate way the lipoids appear to be essential to the irritability of the cell, and altering their state causes corresponding changes of irritability.

About fifteen years ago Overton and Hans Meyer investigated the relation between the lipoid-solvent power of a large number of organic anesthetics and the intensity of their narcotic action, and reached independently the conclusion that the chief factor determining this action was the value of the partition-ratio of the anesthetic between water and a typical lipoid like lecithin. That is, for any series of lipoid-soluble compounds the narcotic action increases as the lipoid-solubility increases and the water-solubility decreases. These two solubilities usually show an inverse relation to each other. Now, the view that this form of anesthetic action depends essentially upon a modification of the cell-lipoids—which was put forward simultaneously and independently by Overton and Meyer—is undoubtedly well founded, and is accepted by most physiologists, even although in the absence of any definite and final knowledge of the physiological rôle

of these cell-constituents it is far from being a complete theory of anesthesia. Such a theory would evidently involve a complete theory of stimulation, and this can hardly be said to exist as yet. It is, however, possible, I believe, to gain further insight into the nature of anesthetic action by combining the results of these and similar experimental studies of anesthesia with the results of certain more recent studies of the nature and conditions of the process of normal stimulation. It is necessary to form some clear conception of the nature of the changes involved in stimulation before we can profitably consider the question of just how the stimulation-process is modified by the presence of the anesthetic.

Before considering in more detail the mechanism of stimulation and of its modification by anesthetics, let us first consider briefly the nature of the physico-chemical constitution of the living cell, as more recent research has led us to conceive of it. This is a subject which is not easy to summarize, and on which much light remains to be thrown. It is clear, however, that the living protoplasm is not a homogeneous solution, but is a "polyphasic system"; *i. e.*, a mixture consisting of various substances and solutions which are only partly miscible with one another, and are thus interrelated like the different phases of an emulsion or similar system. These several phases, which are partly solid, partly liquid, appear in each living cell to have a constant and definite arrangement, whose exact nature varies characteristically from cell to cell. There appears typically to be a solid or semi-solid structural substratum consisting of colloidal material, most of which is in a water-swollen or hydrated state; in addition to this more fixed and permanent part of the cell-organization, numerous simpler substances are present—sugars, salts, amino-acids and others—largely in a state of simple aqueous solution, but probably partly adsorbed at the surfaces of the colloidal phases. There is evidence that it is by the oxidation of certain of these substances, especially sugar, rather than of the colloidal material, that most of the energy manifested in the cell-processes is set free. The colloidal substratum furnishes the conditions under which the energy-yielding oxidations and other metabolic changes take place, and apparently determines their course, character and velocity. The solid colloidal material of the cell may in one sense be considered as by-product of the metabolic activities of the protoplasm; it appears, once formed, to undergo itself relatively slight change, but to influence profoundly, by its presence and arrangement, the character of cell-metabolism.[4] The colloids are of varied chemical nature; they are chiefly proteins and lipoids, and it is to be noted that they are built up by various forms of molecular union and polymerization from relatively simple substances furnished by the environment. This is true not only of plants, but also of the individual cells of higher animals, where the material which goes to form proteins reaches the cell in the form of amino-acids, or of simple polypeptides.[5] In general it is from such amino-acids together with salts and carbohydrates that the cell builds up the colloids which form its characteristic structural apparatus. This appears highly complex in some forms of irritable tissue, as in voluntary muscle; in others, as in nerve, the essential structure appears relatively simple. What we call the "structural organization" of the cell is merely another name for the physical char-

[4] *Cf.* Child's interesting discussion of the relation between metabolism and structure in the *Journal of Morphology*, Vol. 22, 1911, p. 173.

[5] *Cf.* Folin's recent papers in the *Journal of Biological Chemistry*.

acteristics and arrangement of the solid colloidal material.

However simply organized a cell may seem, there are certain elements of structure which appear always to be present, and to play a fundamentally important rôle in stimulation and in other life-processes. These are the *membranes*. Most, if not all, living cells are delimited from the medium in which they live by thin semi-permeable colloidal surface-films, the so-called plasma-membranes. Similar semi-permeable partitions are often found in the cell-interior, *e. g.*, about nuclei, vacuoles, chromatophores, and other structures. They appear to be formed of the same colloids as the other protoplasmic structures, namely, proteins and lipoids. These colloids, like many other organic substances, have, when dissolved in water, a marked influence in lowering the surface-tension of the solvent. Any substance thus acting tends, by the operation of Gibbs's principle, to collect or condense on the free surfaces; if the substance is colloidal in nature it may there pass out of solution and form a solid surface-film or membrane; and it is probably under conditions essentially like these that the cell-membranes are formed. Artificial membranes similar in many of their properties to the plasma or nuclear membranes of cells may be formed in protein solutions about droplets of chloroform, mercury or other water-immiscible substances. Now the plasma-membranes of irritable cells undoubtedly play a fundamentally important part in stimulation, as will be seen below, so that it will be necessary to consider first some of the essential properties of these membranes before passing to the consideration of the stimulation-process itself and its modification by anesthetics.

The plasma-membranes are typically *semi-permeable* structures—so much so that living cells form in many cases the most convenient and rapidly acting osmometers that we possess. If we place living cells, like plant-cells or blood corpuscles, in solutions of sugars, neutral salts and various other substances not in themselves immediately injurious to the cells, osmotic effects result from which the osmotic pressure of the solution relatively to that of the cell-contents can be estimated with great accuracy—as the researches of de Vries, Overton, Hedin and many others have shown. Two provisos are necessary in making use of living cells as osmometers: first, the dissolved substance must not by its own action impair the semi-permeability of the membrane, and second, it must not appreciably penetrate the membrane during the time occupied by the experiment. The plasma-membranes are in fact semi-permeable only in relation to certain classes of substances; towards others they show themselves freely permeable, and the character of these substances is important, because indication is thus afforded of the chemical nature of the materials composing the membranes. This is a matter of fundamental importance in the theory of anesthesia. Let us take for example a tissue composed of typical irritable cells, such as a frog's voluntary muscle. In studying the osmotic properties of this tissue, Overton found many years ago that the cells behaved in solutions of certain substances as if they were enclosed by strictly semi-permeable membranes; the chief of such substances are sugars, neutral salts, polyatomic alcohols like mannite, and amino-acids like glycocoll; but toward a large series of mainly organic substances, including alcohols, esters, aldehydes, hydrocarbon-derivatives and others, the membranes behaved as if freely permeable. Thus in an $m/8$ (0.7 per cent.) solution of NaCl the muscle retains its weight unaltered, neither absorbing nor losing water; similarly in solutions

of sugar, mannite or glycocoll of the same osmotic pressure (of about 6 atmospheres). But if to an $m/8$ NaCl solution we add (*e. g.*) alcohol in sufficient quantity to double the total osmotic pressure of the solution, it is found that there is no perceptible increase in its osmotic action on the muscle; in other words, the alcohol acts as if it entered the cell with the same readiness as the water. Many other substances show a similar power of freely entering the cell; others like urea, glycol and glycerine also enter, but more slowly. Similar observations in both animal and plant cells have shown that readiness of entrance into cells is a property that is closely correlated with solubility in fats or fat-like substances, including lipoids like lecithin. Substances not so soluble usually gain entrance slowly or imperceptibly. Overton drew from these facts the conclusion that the outer limiting layer or plasma-membrane of living cells consists in large part of lipoids, and that the characteristic osmotic properties of the cell depend on the presence of these substances in the membrane. Since substances that dissolve in lipoids will pass readily through lipoid-impregnated partitions, this view explains why plasma-membranes are in fact readily permeable to such substances as a class. In its detailed application Overton's view has met with considerable opposition; thus, according to Overton, intra-vitam dyes like neutral red and methylene blue enter cells readily *because of* their solubility in lipoids; a certain number of exceptions to this rule have been pointed out by Ruhland and others; but in spite of these discrepancies there seems no doubt—when the whole of the evidence is considered—of the truth of Overton's main contention that lipoid-solubility strongly furthers the ready entrance of substances into cells. Traube believes that the degree of surface-activity, rather than of simple lipoid-solubility, is the determining factor; this property shows a general parallelism with the lipoid-water partition-coefficient, and hence also with the readiness of penetration. But there appear to be more exceptions to Traube's rule than to Overton's, while there are other and independent indications that the surface-films of cells are characteristically rich in lipoids; for instance, the fact that in the eggs of sea-urchins and other animals lipoid-solvents are especially effective in causing the formation of fertilization membranes (a typical surface-effect) and in initiating cell-division; also the facts which I shall cite presently, showing that lipoid-solvents are characteristically effective in altering the permeability of the plasma-membranes and in modifying their resistance to alteration by cytolytic substances.

I dwell upon these researches here because of the light which they throw on the question of the constitution of the plasma-membranes of cells, including those of the irritable tissues. They indicate that the membranes—and perhaps surface-structures in general—are especially rich in lipoids. Now lipoid-soluble substances will tend, by the operation of the partition-law, to concentrate in the lipoids of the tissue; they will thus tend to gather in the membranes, and in so doing they will necessarily modify the physical state of these structures and so influence their physiological properties. We have already seen that the most striking effect which lipoid-solvents produce on irritable tissues is to modify their irritability, and under certain conditions to suppress it altogether. This suggests that the membranes have a special relation to stimulation. We should expect on *a priori* grounds that the excitatory apparatus of the cell should be externally situated; and we are thus led to inquire if there is other and independent evidence

that the surface-films or plasma-membranes of the irritable elements play any such special part in stimulation.

There are in fact many indications that this is the case. Investigation of the conditions of electrical excitation—undertaken quite without reference to the problem we are considering—has shown that the semi-permeable membranes of irritable tissues are intimately concerned in stimulation. The first definite proof of this was brought forward in 1899 by Nernst. He was struck with the fact that Tesla currents (or alternating currents of high frequency) may be passed through irritable tissues (or through the human body) without causing stimulation; while if the frequency of the current is sufficiently lowered, but without altering its intensity, strong stimulation results. Now what does this mean? Evidently that the current must flow for a certain minimal time in a *constant direction* in order to stimulate. Mere conduction of a given quantity of electricity through an irritable tissue is not in itself sufficient to cause stimulation. There is some kind of cumulative effect depending on a steady flow in one direction. What physical peculiarities of the living tissue condition this remarkable peculiarity? Nernst pointed out that a living tissue in its relation to the electric current is an electrolytic conductor, which, however, is not homogeneous like an ordinary salt-solution, but peculiar in being sub-divided at intervals by semi-permeable partitions, the cell-membranes. When therefore the current starts to flow it carries as usual anions toward the anode and cations toward the cathode, but at the semi-permeable membranes this movement is blocked; the concentration of anions thus tends to rise above that of cations on the side of the membrane facing the cathode and *vice versa*, and the above behavior of the tissue may be partly explained if we assume that these changes of concentration must reach a certain degree if stimulation is to result. For this effect time is required. Hence, if the current is reversed too soon, the stimulating effect is annulled, and the tissue remains unaffected. Now, if the assumption is true that stimulation is the expression of a change of electrical polarization, due to a change in the concentration of ions at the membranes, the time during which the current must flow in order to produce a given polarization-effect ought to correspond with that needed for a given stimulation-effect. Nernst's analysis shows that the polarizing action varies directly with the intensity of the current (*i. e.*, the quantity of electricity—*i. e*, ions—transported in unit time) and with the square root of its duration ($S = Ki\sqrt{t}$), and observations on a variety of irritable tissues have shown that the stimulating action of a given current does vary in essentially this manner with the duration of its flow in one direction (*i. e.*, inversely with the square root of the number of alternations in the case of an alternating current). It seems clear then that electrical stimulation is dependent on the polarization-changes produced by the current at the semi-permeable membranes of the irritable elements.

One main result of these investigations is thus to localize the stimulating action of the current at the semi-permeable membranes, and to indicate that a change in the electrical polarization of these membranes is an essential feature of stimulation. It is evident that this result does not constitute a complete analysis of the nature of stimulation. But it indicates that some change in the membrane is essential to this process. An electrical variation accompanies every normal stimulation and undoubtedly forms an inseparable feature of the process, but its conditions are still imperfectly under-

stood. There is evidence, however, that it is associated with a definite alteration in the osmotic properties of the membrane. The electrical properties of irritable tissues like muscle indicate that during life there exists permanently in the resting cell a difference of potential, equal roughly to 1/10 volt, between the outer and inner surfaces of the plasma-membrane. When the uninjured outer surface of a muscle or nerve is connected through a galvanometer with the exposed interior of the elements (cut surface) a current, the so-called "demarcation-current," flows from exterior to interior, indicating that the outer surface of the cells or nerve fibers has a higher potential than the interior. This potential-difference appears dependent on the semi-permeability of the plasma-membrane; it is absent in dead cells whose plasma-membranes have lost their semi-permeability, and it is diminished by the application of poisons which impair the normal semi-permeability. Briefly, the demarcation-current potential appears in some way to be inseparably connected with this semi-permeability of the membrane. Ostwald in 1890 suggested a possible explanation of this condition when he pointed out that a membrane might become the seat of a potential difference by interfering unequally with the diffusion of the anions and cations of an electrolyte contained within the cell. If the plasma-membrane allowed cations to pass outward freely, but prevented the passage of anions, a state of things would be produced comparable to what we observe in living cells. But the actual conditions are probably more complex than this, and experimental substantiation of Ostwald's suggestion has not been satisfactory. The subject is evidently one requiring further investigation. In any case, however, the existence of the demarcation-current potential appears dependent on the semi-permeability of the membrane, and whenever the latter undergoes marked increase of permeability, this potential is invariably decreased. The electrical variation or action-current which normally accompanies stimulation may be theoretically accounted for by assuming that at this time the membrane undergoes a decided but temporary increase in permeability, *i. e.*, loses the semi-permeable properties which it possesses during rest, and there is independent evidence that this change actually occurs during stimulation. If this is the case the plasma membrane is the seat of the most constant and characteristic manifestation of stimulation—the electrical variation or action-current. The membrane responds to the stimulating condition by suddenly changing its permeability and hence its electrical polarization.

We are thus brought to the conclusion that the plasma-membrane is characteristically and intimately concerned in the stimulation process. During stimulation it appears to undergo a sudden and quickly reversible increase of permeability. The electrical variation is one expression of this change, but there are others as well. Thus the movements of sensitive plants, which occur under the same conditions of stimulation as those of irritable animal tissues, are due to a collapse of turgid cells, consequent upon a sudden loss of the semi-permeable properties of the plasma-membranes enclosing the osmotically active solution or cell-sap. Here at least is one irritable tissue where the connection between permeability-increase and stimulation seems unmistakable. It might be held that the existence of special osmotic motor mechanisms in certain plants affords no indication of the nature of the conditions in irritable animal cells; but even in animals there are in some cases very clear indications that stimulation is constantly associated with an increase

of permeability, as I shall shortly point out. Evidence from various sides thus proves the participation of the plasma-membranes in the stimulation-process. Just why a change in the permeability and electrical polarization of the plasma-membrane should influence so profoundly the metabolic and other activities of the cell is naturally a far-reaching question requiring further investigation, but there are many reasons for believing that the primary or initiatory phase of the stimulation-process is a change of this nature.

Let us return now to the question of why anesthetics interfere with the stimulation-process. In the first place they can be shown experimentally to interfere with both of the above characteristic manifestations of stimulation, (1) the action-current and (2) the change of permeability. If these are the critical or primary events, on which the other effects following stimulation depend, it is evident that suppression of these must involve a suppression of the entire series of processes resulting from stimulation, including the oxidations, the contraction-changes and the other special features of the response.

That the action-current as well as the mechanical response of a muscle is suppressed by anesthetization has long been known. In nerve also anesthesia abolishes the action-current. Now, on the foregoing hypothesis, the electrical variation is the expression of some alteration in the plasma-membrane, involving a temporary increase of permeability. Höber has found that potassium salts, which deprive nerves of irritability and render them locally negative, cause at the same time a visible alteration in the axis-cylinders; these structures swell and stain more diffusely; he found further that these effects are checked or prevented if the nerves are first anesthetized with ethyl urethane. Experiments on voluntary muscle gave analogous results. If a frog's muscle is partly dipped into an isotonic solution of a potassium or rubidium salt the tissue contracts somewhat and becomes locally negative; this effect is also inhibited or retarded in the presence of an anesthetic.[6] If the local negativity is the expression of a change produced by the salt in the colloids of the plasma-membrane, rendering the latter more permeable than before, Höber's results indicate that the anesthetic decreases the susceptibility to such changes of permeability. If this is the case we can partly understand why the anesthetized tissue becomes less susceptible to stimulation, since stimulation involves an increase of permeability.

Quite recently at Woods Hole I have investigated the question of the nature of anesthetic action in a somewhat different manner, using an organism which seems unusually well adapted to throw clear light on this subject. If an anesthetic acts by so modifying the plasma-membrane of the irritable cell as to render difficult or impossible the rapid variations of permeability which are essential to stimulation, it ought to act similarly on other cells, *i. e.*, it should protect these cells also against the action of permeability-increasing substances or agencies. If an organism can be found whose cells undergo immediate and obvious increase of permeability under conditions which at the same time cause stimulation, it should become possible to determine whether suppressing the stimulating action of a given agency is equivalent to a suppression of its permeability-increasing action. The two effects ought to show a definite parallelism if the above hypothesis is well-based. The organism which I have used is the larva of the marine annelid *Arenicola cristata*. This organism shows

[6] *Cf.* Höber, *Pfluger's Archiv*, 1907, Vol. 120, p. 492.

anatomical features of the required kind. It is a small, worm-like trochophore about 0.3 mm. long, swimming by two ciliated rings and possessing a well-developed musculature of longitudinal fibers. The body cells are permeated with a yellow or brownish pigment, so that when the larvæ are collected in a dense mass (which can readily be done by taking advantage of their strong heliotropism) they appear dark brown in color. Now if such a mass of larvæ is brought suddenly into a pure isotonic NaCl solution, they instantly contract strongly and remain thus contracted for twenty or thirty seconds, after which they slowly relax. During the period of contraction the yellow pigment diffuses rapidly into the solution and colors the latter bright yellow; *i. e.*, strong stimulation of the muscle cells is associated with marked increase in the permeability of the pigment-containing cells. The cilia cease and undergo rapid disintegration at the same time. If now instead of using pure NaCl solution, we bring a similar mass of larvæ into NaCl solution to which a little calcium or magnesium chloride has been added, a strikingly different effect is seen. Stimulation is slight and transitory, there is no immediate loss of pigment, and ciliary action continues uninterrupted. The general toxic action of the NaCl is also greatly lessened. It can thus be shown that pure solutions of sodium salts cause strong stimulating and permeability-increasing effects, both of which are simultaneously prevented by the addition of a little calcium or other antitoxic salt. Prevention of permeability-increase runs parallel with prevention of stimulation. Magnesium salts in pure isotonic solution exhibit an action which is apparently the reverse of that shown by sodium salts. Larvæ brought into $m/3$ $MgCl_2$ show no stimulation, no loss of pigment or destruction of cilia, and little or no immediate injury. On the contrary all muscular movements cease in a few seconds and the larvæ remain permanently motionless during their stay in the solution (except for the cilia which remain active). The effect of the solution is reversible; on return after a few minutes to sea-water, the normal activities at once return. The magnesium salt shows typical anesthetic action, *i. e.*, it renders stimulation difficult or impossible. It also hinders increase of permeability. If larvæ that have lain in $m/3$ $MgCl_2$ for a few minutes are suddenly brought into $m/2$ NaCl, no immediate effect is seen—neither stimulation nor loss of pigment. The toxic action of the pure NaCl is also much less than when the transfer to this solution is made directly from sea-water. In other words, the $MgCl_2$ renders the plasma-membranes resistant to the permeability-increasing or cytolytic action of the NaCl solution; and at the same time it renders the irritable elements resistant to stimulation. The action of the $MgCl_2$ must depend on an alteration of the cell-surfaces, since this salt enters living cells with extreme slowness, if at all. We must conclude that in this instance at least the anesthetic action depends on a modification of the surface-layers or plasma-membranes of the irritable cells or elements.

I have found that lipoid-solvent anesthetics produce effects which are essentially identical with those of $MgCl_2$. The case of ethyl ether, the most widely used of all anesthetics, may serve as an illustration. In a .7 per cent. solution of ether in sea-water *Arenicola* larvæ immediately cease all muscular movements; the cilia show more resistance to anesthesia and remain active. If now the larvæ are transferred to $m/2$ NaCl solution containing the same proportion of ether—so as to preserve the state of anesthesia—no contraction or loss of pigment follows, the cilia continue their activ-

ity, and the injurious action of the pure NaCl is relatively slight. Bringing larvæ from normal sea water directly into ether-containing NaCl solution also causes little or no stimulation or loss of pigment, and the cilia and body cells are protected against the injurious action of the solution. Thus in the presence of the anesthetic the salt solution fails to show its normal stimulating and permeability-increasing action, and its toxic or cytolytic action is greatly diminished. Anti-stimulating and anti-cytolytic actions run parallel with each other.

I have studied the action of a large number of anesthetics in this manner. Those which promptly and completely anesthetize *Arenicola* larvæ in sea-water show, when dissolved in NaCl solution in the proper proportions, effects which are essentially identical with those just described, though varying in degree with the different anesthetics. Alcohols (methyl, ethyl, propyl, butyl, amyl, capryl), the urethanes (methyl, ethyl, phenyl), other esters like ethyl nitrate, acetate, propionate, and compounds like chloretone, acetanilide, paraldehyde, nitromethane, chloroform, acetonitrile, all decrease or prevent the stimulating and permeability-increasing action of pure NaCl solutions when present in the concentrations which cause typical anesthesia in sea-water. They also show well-marked protective or anti-cytolytic action. Other anesthetics, among which are chloral hydrate, benzol, phenyl urea, and chloralose, act more slowly than those just mentioned, and if larvæ are brought suddenly into their solutions in $m/2$ NaCl, stimulation and loss of pigment occur very much as in the pure salt solution. A parallelism between permeability-increasing action and stimulating action is thus seen throughout. If the one effect is decreased or prevented so also is the other.

The exact concentrations most favorable for anesthesia and prevention of permeability-increase are characteristic for each substance and have to be determined empirically. In a series of homologous compounds, like the alcohols or the fatty acid esters, the molecular anesthetic action increases rapidly with increase in molecular weight and in lipoid-water partition-coefficient. The same is true for the vertebrate central nervous system, as Overton and Meyer have shown. Overton's observations on tadpoles show a close parallelism with my own in these respects. The concentrations required to anesthetize *Arenicola* larvæ are, however, higher in every case—usually three to five times higher—than for tadpoles. Possibly the higher salt content of the tissue-media in marine animals is responsible for these differences; the order of relative action is the same in both organisms.

To sum up—it would thus seem that anesthetics produce their essential effects by modifying the properties of the semi-permeable plasma-membranes of the irritable tissues, making these structures more resistant to changes of permeability than normally. Since variations of permeability are essential to stimulation, the irritable tissue is thus rendered temporarily insensitive or irresponsive.

How does the anesthetic produce these effects? Osterhout has recently shown that anesthetics decrease the electrical conductivity of plant tissues, apparently by decreasing the permeability of the plasma-membranes to ions;[7] and it may be that in irritable animal tissues also the permeability normal to the membranes is similarly decreased during anesthesia. If the distinctive action of the anesthetics is to *decrease* permeability, its presence in the tissue will naturally oppose increase of per-

[7] Science, Vol. 37, 1913, p. 111.

meability and hence interfere with stimulation. The osmotic motor mechanisms of plants, whose action depends on sudden increase of permeability, may in fact readily be rendered irresponsive by anesthetics, as Claude Bernard pointed out long ago in his classical lectures on the life-phenomena common to animals and plants. Or the explanation may be somewhat different. The anesthetic may leave the resting permeability of the membrane the same as before—or perhaps may change it in either direction—but alter its properties so as to decrease the readiness with which the permeability is changed by other agencies acting on the membrane. Changes of condition, electrical or otherwise, that normally act as stimuli would then no longer affect the membrane, and would hence cease to stimulate. But whatever general interpretation we adopt, it is demonstrable that the properties of the membranes are altered during anesthesia in such a way as to make increase of permeability more difficult than in the normal sensitive state of the irritable tissue.

Is this the whole explanation of the anti-stimulating action of anesthetics? Nothing but further experimentation can answer such a question. Suppression of stimulation is however the essential effect to be explained. It must be remembered that any specific response to stimulation comprises a series of mutually interdependent processes, beginning with the one caused directly by the external agent, and ending with the special physiological activity, or response, characteristic of the tissue. It seems more likely that the anesthetic interferes with the *initial* process of such a series than with one occurring later—such as the increase in oxidation or other special effect. The evidence which I have cited indicates in fact that the primary process in stimulation is a *membrane-process,* and that it is this process which is modified by the anesthetic. This is why the succeeding and outwardly more evident effects of stimulation are also modified in the way that we observe.

It is well known that an influential group of physiologists, headed by Verworn, maintain that a suppression or prevention of oxidation-processes is the essential basis of anesthesia. Various facts are adduced in support of this theory. During anesthesia the oxidative metabolism of the tissue is diminished. This fact in itself is equivocal; stimulation causes increased oxidations in many tissues, and suppression of stimulation prevents this effect along with the others. Lack of oxygen arrests many physiological activities that are dependent on its presence, but this fact again does not justify Verworn's identification of narcosis and asphyxia. Other facts seem more consistent with this view. Fröhlich and Heaton find that the recovery of nerves from anesthesia is imperfect or delayed in absence of oxygen; Ishikawa, another pupil of Verworn's, finds the same for Amœbæ; from which they conclude that suppression of oxidations is the essential feature of the condition. These observations merely show once more that the cell or tissue requires oxygen in order to exhibit its normal properties. Mansfeld finds that the concentration of anesthetic required to anesthetize tadpoles is less when oxygen is deficient than when it is abundant; *i. e.,* anesthesia and asphyxia show additive relations to each other. This again is equivocal. The action of nerve-cells is intimately dependent on a good supply of oxygen; when oxygen is deficient their excitability is lowered, and along with this the degree of anesthesia required to abolish excitability. Other parallels of similar nature seem open to objections of the same kind. On the other hand, nerve trunks resist the lack of oxy-

gen or the presence of cyanide (which renders unavailable the oxygen present) remarkably well. Warburg finds that fertilized sea-urchin eggs anesthetized by phenyl urethane, so as to be incapable of cell-division, show nevertheless the same oxygen-consumption as the normal unanesthetized eggs. Again, lack of oxygen interferes only gradually with the ciliary action in many organisms, while anesthetics in sufficient concentration arrest the movement instantly. It seems necessary to conclude from these facts that the essential action of the anesthetic is of a more general kind, and consists in incapacitating some mechanism which is essential to the normal activities of the cell, whether these immediately require oxygen or not.

The evidence which I have reviewed indicates either that this mechanism is the plasma-membrane itself, or that it is closely dependent on the condition of the plasma-membrane. Any condition that renders the membrane incapable of responding to changes of condition by rapid changes of permeability and of electrical polarization has an anesthetic influence. This modification in the properties of the membrane may be produced either by changing the general condition of the colloids forming it—as in the case of magnesium salts or electrolytes in general—or by specifically altering the state of the lipoid-components, as by organic anesthetics. It is impossible to say at present precisely why the solution of an anesthetic in the lipoids of the membrane should thus alter the properties of this structure. The nearest physico-chemical analogy seems to be the so-called "protective action" of colloids, as exemplified in those cases in which the presence of one colloid interferes with or prevents changes of aggregation-state in another, *e. g.*, when gelatine prevents the precipitation of colloidal gold or platinum by a neutral salt like sodium chloride. Apparently the lipoids are related to the other colloids of the membrane in such a manner that the condition of the lipoids affects the entire properties of the colloidal structure, and so determines the effect which an electrolyte like NaCl, or a stimulating condition like an electric shock or mechanical impact, may have upon it. Hence when a lipoid-solvent acts upon the membrane, and dissolves in the lipoids of the latter, it may profoundly change the physical properties of the membrane and hence the responsiveness of the whole tissue or organism to stimulation. On this view the membrane is a main controlling factor in cell-processes, and by changing its state we may alter the entire physiological activity of the cell.

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PSYCHOLOGISTS AS ADMINISTRATORS[1]

Casual statements have frequently been made to the effect that many psychologists leave their professional careers to become administrators of one sort or another, or carry on executive work of a definite kind in addition to their activities as psychologists, with the appended implication that psychology, as a science, suffers a proportionately greater loss of effective workers on this account than do the other sciences. As illustrations of this loss, not a few well-known examples are cited. At first blush, the generalization thus made might be classed under the fallacy of *post hoc, ergo propter hoc,* but in order to escape this charge ourselves, we must submit the matter to some statistical presentation.

The executive positions to which academic men are obviously called are presidencies of colleges and universities, and deanships of departments within colleges and universities. Farther down the scale, viz., directorships of laboratories and headships of divisions and

[1] Read before the meeting of the Experimental Psychologists at Wesleyan University on April 12, 1913.

specific departments, the positions are often only nominal in nature and vary so much from place to place in their attached duties that it does not seem wise to include them in our discussion. The question arises, then, as to which disciplines out of a given group contribute the most men for these executive positions and in what proportions they contribute them. To answer this we selected, from a list of colleges and universities in the United States for the year 1910–11,[2] those institutions which are neither denominational nor technically specialized. This list of 177 institutions was subdivided into those whose enrollment of students was above the 1,000 mark and those whose enrollment was below that mark, with the hope that this crude distinction between the large institution and the small might bring to light a difference in the kind of administrator demanded. The names of the presidents were then looked up in "Who's Who in America" in order to determine their fields of professional interest before they assumed charge of their administrative work. Where interest was considered to be equally divided in several fields, the count was fractionated accordingly. The results are thrown into two classifications: the first may be considered as absolutely determined, the other as relatively determined. Concretely, in the first case, the disciplines are presented in order of rank based upon the per cent. of representation in all the disciplines found; in the second case, a half-dozen sciences are chosen, and the relative rank of representation is given in terms of a per cent. based upon the total representation in these few sciences. The selection of these sciences was made on the basis of a possible comparison of relative worth. Unfortunately there were no available statistics for all disciplines dealt with in the first classification, but in the "Biographical Directory of American Men of Science,"[3] the author found a scale of proportionate values which served as a means of possible interpretation in the second classification. In this directory of over 4,000 names, the relative number of men engaged in about a dozen sciences is given. Some of these sciences are not represented in our lists and are, therefore, not relevant to this discussion. We are forced to limit ourselves, consequently, to the following six sciences to which are attached the corresponding relative per cent. of men engaged in the given activity on the basis of the total number engaged in all of the six activities: biology (27 per cent.), chemistry (22 per cent.), physics (21 per cent.), geology (14 per cent.), mathematics (10 per cent.), and psychology (6 per cent.). The same method of classification was used with a list of 97 deans of colleges and of college departments of universities which were not specialized in profession, *i. e.*, schools of "applied science," "engineering," "medicine," "theology," etc., were not considered because they usually always demanded an executive whose interest lay in the corresponding field of activity. These names were chosen from the 1910–11 catalogues of 42 leading colleges and universities.

[2] This list was furnished by the *World's Almanac* for that year and corroborated by reference to the Report of the Commissioner of Education for the same year.

[3] New York, 1911.

CLASSIFICATION 1

111 Presidents of Institutions below 1,000 Student Enrollment	Per Cent.	66 Presidents of Institutions above 1,000 Student Enrollment	Per Cent.	97 Deans	Per Cent.
Theology	23	Education	20	Mathematics	16
Mathematics	13	Chemistry	15	Class. Lit	12
English	10	Philosophy	10	English	12
Education	8	Mathematics	9	History	10
Mod. Lang's	7	Polit. Science	9	Polit. Science	10

CLASSIFICATION 2

28 Presidents of Institutions below 1,000 Student Enrollment	Per Cent.	21 Presidents of Institutions above 1,000 Student Enrollment	Per Cent.	38 Deans	Per Cent.
Biology	5		7		11
Chemistry	33		11		13
Physics	24		14		23
Geology	5		4		2
Mathematics	28		52		40
Psychology	5		12		11

The totals for the second classification are: biology 7.7 per cent., chemistry 19 per cent., physics 20.3 per cent., geology 3.7 per cent., mathematics 40 per cent., and psychology 9.3 per cent.

These tables show, then, that (1) under the absolute classification in the first array, psychology does not appear at all in the rank of the first five disciplines represented, but that (2) under the relative classification of our second array, whereas psychology has the fewest number of representatives engaged in activity in its field, it stands, on the average, fourth on the list of executive representatives, and, if we get its comparative rank in terms of the relative number engaged in the profession, we find that it stands next to the top. This result was obtained by dividing the average per cent., as given in the second table, by the per cent. of number engaged in the profession as outlined above. This value might be termed, for the sake of this discussion, the efficiency-value and results as follows: mathematics 4.00, psychology 1.55, physics .94, chemistry .86, biology .29, and geology .24.

Another investigation was carried on from a slightly different angle. This study was not, like the second classification, a comparative one in terms of other sciences. The question arose as to how many psychologists of repute have been engaged in executive work since they began activity in the field of the science. For this purpose the membership list of the American Psychological Association and Cattell's "American Men of Science" (2d, 1911, edition) were consulted. From the former, a list of about 300 names, 150 names of persons who were recognized in the latter as psychologists were drawn. These names were subdivided into two groups: those recognized as eminent, *i. e.*, among the 1,000 scientists of the country, and, the remainder, those who were not so considered. It was deemed that they had performed executive work if, after they had held some responsible position in psychology, they had become administrators in the sense of the above classifications, or if they had held, or were holding, such positions as superintendencies or principalships of schools, directorships of institutions, or other equivalent positions. It was found that in the first group there were 12 executives out of a possible total of 42 (29 per cent.), and in the second group 36 out of 108 (33 per cent.) came under the rubric of executives. This, the investigator believes, is a fairly large portion of the total, but there is, of course, no ground for believing that psychology is making a better showing in this respect than other sciences, except in so far as the second classification, given above, distinctly indicates it. Undoubtedly, on the score of this classification, the conclusion that psychology, next to mathematics, is contributing more executives relatively than the other sciences mentioned, is valid; and the supposition that the comparison between these sciences, chosen only with reference to available statistics, is fair, must be left to the judgment of the readers of this article.

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THE PLANT INDUSTRY HALL OF THE UNIVERSITY OF NEBRASKA

On June 10 the University of Nebraska dedicated a new building known as the Plant Industry Hall, to be occupied by the departments of agricultural botany, in charge of Professor Wilcox; horticulture, in charge of Professor Emerson, and entomology, in charge of Professor Bruner. The new building is 140 by 65 feet, and consists of three stories above the basement. It is of strictly fireproof construction throughout.

Short addresses were made by Architect Chowins, Regent Whitmore and Dean Burnett. The principal address on "Practical Science" was given by Professor Dr. John M. Coulter, of the University of Chicago, and will be printed in Science. These addresses were followed by the ceremony of conferring the honorary degree of doctor of agriculture upon Dean Herbert J. Webber, of the University of California, and Dean Albert F. Woods, of the University of Minnesota.

In conferring these degrees, Chancellor Avery said:

Herbert John Webber, bachelor of science; master of arts; doctor of philosophy; charter member Botanical Seminar, and early assistant in the department; distinguished physiologist, pathologist, and plant breeder; discoverer of motile sperms in *Zamia;* investigator of double fertilization in maize; improver of plants useful for food and clothing; member of learned societies.

Albert Fred Woods, bachelor of science; master of arts; charter member Botanical Seminar, and early assistant in the department; notable investigator; as an administrator distinguished for services in the United States Department of Agriculture; dean of a great college of agriculture; director of a famous experiment station; author and man of affairs.

THE PHYSICAL LABORATORY OF WASHINGTON AND JEFFERSON COLLEGE

THROUGH the generosity of an alumnus, $50,000 was given to Washington and Jefferson College in June, 1911, for the erection of a physics laboratory. An attempt was made to keep within the appropriation, but the cost of erection ran up to $51,090. It is built of cream-colored brick, and measures 60 by 90 feet. The floors are of reinforced concrete, while the walls are solid brick 22 and 18 inches thick. All the laboratories are provided with piers running down to the rock underneath the building or with slate ledges built into the wall. The first floor contains elementary laboratories, workshop, storage room, constant temperature room, and one private laboratory. On the second floor are laboratories for work in electricity and light. Besides there is a chemical laboratory, a supply and stock room, and two private laboratories for advanced work. The third floor is given over to the lecture room, with accompanying preparation and apparatus rooms, a general laboratory for work in mechanics, a dark room, and a laboratory for advanced optics. Electric power is distributed from the dynamo room on the first floor, while the battery distributing center is on the third floor. A reference library and reading room is located on the second floor. The laboratories are all supplied with gas, hot and cold waters, compressed air and exhaust; also, direct, alternating and battery currents are available in each laboratory for power and experimental purposes.

The laboratory was dedicated on January 16, 1913, celebrating the 111th anniversary of the chartering of Jefferson College at Canonsburg. The address was made by Professor A. G. Webster on "Physical Laboratories and their Relation to the Advance of Civilization."

SCIENTIFIC NOTES AND NEWS

HARVARD UNIVERSITY has conferred its doctorate of science on Dr. Chas. D. Walcott, secretary of the Smithsonian Institution.

AMONG honorary degrees conferred by Yale University were doctorates of science on Dr. A. A. Noyes, professor of theoretical chemistry of the Massachusetts Institute of Technology, and on Dr. S. W. Williston, professor of paleontology at the University of Chicago; the doctorate of laws on Dr. John G. Hibben, president of Princeton University, and Dr. David F. Houston, secretary of agriculture, and the master of arts on Dr. Harvey Cushing, professor in the Harvard Medical School.

THE University of Pennsylvania has conferred its doctorate of laws on Dr. G. W. Goethals, chief engineer of the Panama Canal.

BROWN UNIVERSITY has conferred the degree of doctor of science on Mr. Frank M. Chapman, curator of ornithology in the American Museum of Natural History.

WESLEYAN UNIVERSITY has conferred the doctorate of laws on Dr. Charles H. Judd, director of the school of education of the University of Chicago.

TUFTS COLLEGE has conferred the doctorate of science on Admiral Robert E. Peary and the degree of doctor of science on Dr. Alfred C. Lane, Pearson professor of geology and mineralogy in Tufts College.

DURING commencement week at Colorado College there was celebrated the twenty-fifth anniversary of President W. F. Slocum's administration. The following honorary degrees were conferred on scientific men: the degree of doctor of science on Professor T. D. A. Cockerell, of the University of Colorado,

and on Professor William Strieby, of Colorado College, and the degree of doctor of laws on H. A. Howe, of the University of Denver.

Dr. John M. Mecklin has resigned the professorship of mental and moral philosophy at Lafayette College because his teaching was regarded as not in accord with the standards of the Presbyterian church.

The first Loubat prize of $1,000, for the best work printed and published in the English language upon the history, geography, archeology, ethnology, philology or numismatics of North America, during the quinquennial period ending July 1, 1913, has been awarded by Columbia University to George Louis Beer, of New York (A.B., 1892), for his series of works on the British Colonial System. The second prize of $400 has been awarded to Dr. John Reed Swanton, of the Bureau of Ethnology, Washington, D. C., for his two works, one on "The Indian Tribes of the Lower Mississippi Valley," and the other, "Tlingit Myths and Texts."

The Académie Française has awarded the Grand Prix Broquette Gonin, of the value of $2,000, to Professor Grasset, of Montpellier. The prize is for "the author of a work, philosophic, political, or literary, which shall be judged to be of a nature to inspire the love of the true, the beautiful, and the good." Professor Grasset, who is known for his researches on the nervous system, is also the author of several works on questions of psychology, moral responsibility and the philosophy of practical life.

Professor Robert Andrews Millikan, of the department of physics in the University of Chicago, was elected on May 23 president of the local chapter of Sigma Xi. Dr. Henry C. Cowles, of the department of botany, was elected vice-president of the chapter, and Dr. Rollin T. Chamberlin, of the department of geology, secretary.

Dr. Henry A. Bumstead, professor of physics in Yale University, has been given leave of absence for the coming academic year.

Professor Edward Alexander Westermarck, professor of sociology in the University of London, has accepted an invitation to give four lectures next year at Brown University.

Dr. C. S. Sherrington, F.R.S., professor of physiology at Liverpool, has been appointed an additional member of the British departmental committee on the lighting of factories and workshops.

Mr. A. J. Mutchler has been appointed assistant in the department of invertebrate zoology of the American Museum of Natural History.

Mr. A. C. Fraser, of Cornell University, has come to the New York Botanical Garden to assist during the coming summer in the experimental work in plant breeding.

Dr. John Detlefsen, assistant professor of genetics in the University of Illinois, will spend the summer visiting the principal European genetic laboratories.

Nelson C. Brown, M.F., Yale Forest School, in charge of forest utilization in the New York State College of Forestry, is spending the summer studying forest conditions in Germany and Austria.

The Amazon expedition of the University of Pennsylvania, in charge of Dr. W. C. Farabee, arrived in Para, Brazil, last week. Here Dr. Farabee will charter a vessel for the trip in the Amazon regions, according to the original program. The Brazilian government is interested in the expedition, and is aiding the university in various ways.

Dr. Frank Hartley, professor of clinical surgery in Columbia University, has died at the age of fifty-nine years.

The U. S. Civil Service Commission announces an examination for assistant in plant histology, on July 16, to fill a vacancy in this position in the Bureau of Plant Industry, Department of Agriculture, at a salary ranging from $1,200 to $1,620 a year.

The material collected by the third African expedition, under Dr. W. S. Rainsford, has been received at the American Museum of Natural History. It contains specimens of

black rhinoceros, East African buffalo, eland, leopard, cheetah, antelope and monkey.

THE Tokyo Statistical Society of Japan, having recently suffered the loss by fire of a valuable library it had been thirty-three years in gathering, John Hyde, former statistician of the Department of Agriculture, has presented the society with 3,000 volumes of statistical literature to form the nucleus of a new collection. In addition to official publications of 52 countries, printed in twelve different languages, the gift includes the transactions for a long series of years of most of the leading statistical societies of the world, as well as a large number of miscellaneous books of reference. In accepting the gift, the president of the society, Baron Sakatani, former finance minister, announced that the library would be given the name of the donor.

AN ecological conference will be held at the University of Chicago during the summer quarter; the following series of illustrated lectures on "The Relation of Plants and Animals to Environment," will be given beginning July 16, when Professor Henry C. Cowles, of the department of botany, will speak on "Principles and Problems of Ecology as illustrated by Plants." On July 18 Dr. Victor E. Shelford, of the department of zoology, will discuss "Principles and Problems of Ecology as illustrated by Animals." Lecturers in the conference from other institutions will include Arthur C. Tansley, of Cambridge University, who speaks on "British Landscapes"; Professor Carl Schröter, of the University of Zurich, on "The Lake Dwellings and Lake Dwellers of Ancient Switzerland"; Professor Stephen A. Forbes, of the University of Illinois, whose subject is "Fish and their Ecological Relations," and Professor William M. Wheeler, of Harvard University, who will discuss in two lectures "The Habits of Ants."

IT is difficult to realize the enormous quantities of brick used annually in Greater New York. During 1912 the consumption was over 1,000,000 thousand. The principal source of this vast quantity is the Hudson River region, which extends along both sides of the river from New York City to Cohoes and embraces ten counties, nine in New York and one in New Jersey. Other sources of supply are the Raritan River region of New Jersey and the Connecticut region. The year 1912 was one of unusual interest in the Hudson River region. It opened with an increasing demand for brick, and the price for common brick was $7 a thousand, compared with $4.25 in 1911. For several years the use of cement or concrete in construction appeared to be displacing brick to some extent, but owing to the strong "back to brick" movement the year 1912 saw in the New York market a change favoring brick as the best building material for many purposes. Influences that have contributed to this change are the failure of some concrete buildings, the advertising campaign carried on by the brickmakers, and the improved quality of the Hudson River brick. The average price was the highest since 1906. The marketed product in 1912 was larger than that of 1911 and would probably have been still greater but for the scarcity of labor, especially at Haverstraw, and the strike among the brickmakers in the Newburgh district. The strike, however, was of short duration, but the scarcity of labor drawn away by large construction enterprises, such as the Catskill aqueduct, railroad extensions and subway operations, was a serious drawback to the Hudson River brickmakers in 1912. This condition was so serious that the operators resorted to night work and rainy-day work in loading barges and imported laborers from the South. An important development during the year was a large increase in the use of Raritan River brick in New York City, which has for some years been drawing on the Raritan River region. In 1912 the demand for this brick was very much greater than ever before. On the whole the year may be considered one of prosperity. The demand was good, prices were high, the mild weather toward the end of the year permitted shipments to its very close, and while the marketed product was not the largest recorded, it was considerably larger than that of 1911. The statistics gathered by Jefferson Middleton, of the United States Geological

Survey, show that the number of brick marketed in the Hudson River region in 1912 was 1,019,259,000, valued at $5,850,770, or $5.74 a thousand, compared with 926,072,000 brick in 1911, valued at $4,717,633, or $5.09 a thousand. This was an increase in 1912 of 93,187,000 brick and of $1,133,137 in value. The number of operating firms reporting in 1912 was 126. As in other branches of the clay-working industry, the number of active firms reporting is not equivalent to the number of yards, for many firms have more than one yard.

UNIVERSITY AND EDUCATIONAL NEWS

Wellesley College has received an anonymous gift of $100,000.

In addition to $250,000 appropriated for a building for the New York State College of Forestry at Syracuse University, the legislature appropriated $50,000 for the maintenance and development of the work for the coming year. Last year through the kindness of Mrs. Russell Sage, who gave something over $80,000, a Division of Agriculture was organized at Syracuse University. This division is giving agricultural instruction for teachers and general work for students of other colleges. These courses in agriculture are given without state or national aid.

Governor Sulzer has signed a bill making the New York American Veterinary College, allied with New York University, the state veterinary college for the eastern part of the state. No appropriation of money was made in the bill.

Sophie Newcomb College, the woman's department of Tulane University, will shortly erect on its new site on Audubon boulevard, adjoining the university proper, four new buildings to cost $600,000.

It is announced that the executors of the late Sir J. Wernher, Bart., have completed the allocation of the £100,000 bequeathed to them to be devoted to charitable and educational purposes. £35,000 has been allotted to charitable and educational purposes in South Africa, and £65,000 to some 150 different institutions in Great Britain. The grants for scientific and educational purposes include: to the Institute of Mining and Metallurgy, £5,000; the Imperial Service College, Windsor, £2,500; the London School of Tropical Medicine, £1,500.

The school of medicine of the University of Pittsburgh arranged a medical program in connection with the commencement week exercises. Special clinics were arranged at the hospitals affiliated with the university, as well as laboratory demonstrations at the medical school building on the university campus.

The Rush Medical College, Chicago, which has for a number of years strongly recommended a fifth clinical year as interne in a hospital, or its equivalent, has made this compulsory for the class entering in 1914. This fifth year is to be spent either in graduate work in one of the departments of the college or as an interne in an approved hospital under the constant supervision of the college faculty.

A great increase in the enrollment has marked the progress of the college of agriculture of the University of Illinois during the past few years. In 1895–96 there was a total enrollment of 14 students; in 1900–01, 159 students; in 1909–10, 660 students and in the present year, 1912–13, there was a total number of 905. The college of agriculture is graduating an ever-increasing number of men. The larger percentage of these graduates are now engaged in practical agriculture. This is shown by statistics being gathered at the present time. Out of ninety-three men graduating this year, forty-four expect to go into actual farming operations; ten expect to enter experimental work at the University of Illinois; ten to teach; eleven will do graduate work; five are going to work for large implement companies, and the rest will be employed in work more or less connected with agriculture.

Dr. L. H. Bailey has resigned the directorship of the New York State College of Agriculture, Cornell University.

Dr. Paul G. Woolley, dean of the medical department of the University of Cincinnati, has resigned this office but retains his professorship.

THE presidency of Tulane, vacant by the resignation of President Craighead a year ago, has been filled by the election of Professor Robert Sharp, dean of the graduate school, acting president during the past year, and for thirty-two years a member of the faculty.

MR. GEORGE WHEELER HINMAN, until recently editor and proprietor of the Chicago *Inter-Ocean,* has been elected president of Marietta College to succeed the late Alfred T. Perry.

MISS JOSEPHINE T. BERRY, of the Washington State College, has been elected professor of nutrition and home economics at the University of Minnesota.

HARRY G. HAKE, of the University of Illinois, has been appointed assistant professor of electrical engineering at Washington University. Joseph C. Stephenson has been appointed instructor in zoology.

AT Vassar College Winifred J. Robinson, Ph.D. (Columbia, 1910), has been advanced from instructor to assistant professor of botany.

MR. W. A. MACDONALD, B.S.F. (Michigan Agricultural College, 1913), has been appointed instructor in forestry in the New York State College of Forestry at Syracuse University.

DISCUSSION AND CORRESPONDENCE

THE LAWS OF NOMENCLATURE IN PALEONTOLOGY

TO THE EDITOR OF SCIENCE: In the course of an interesting and able communication by Dr. Matthew upon "The Laws of Nomenclature in Paleontology" in SCIENCE of May 23, 1913, pp. 788–792, the following paragraph occurs on page 792. The italics here are those of the present writer.

> *Deinodon* Leidy is determinable as to family, but is not determinable generically, as the genera of carnivorous dinosaurs are *now* distinguished. The same is true of a whole series of genera and species described by Leidy and Cope from the Judith River. The treatment of types and referred specimens of these genera by paleontologists as specifically distinguishable or identical has *sadly misled* Dr. Peale in his recent discussion of the vertebrate evidence as to the age of the Judith River beds, leading him to present as conclusive *evidence of identity in age a correspondence in fauna* which to those who know the nature of the specimens on which the lists are based is no evidence at all.

Inasmuch as the writer hereof is mentioned in this paragraph and this mention may lead to some misapprehension, the following notes are presented. Now as to *Deinodon,* it is submitted that what has been done or is to be done with this genus in the future does not seem to enter the case. Suffice it to say that not only is it mentioned generically by Hatcher and others, but Hatcher in Bulletin 257 of the U. S. Geological Survey (p. 85) gives also a number of species of the genus, and I believe that I am not assuming too much when I take it for granted that others who have referred to these species, or any of them, were referring to the same thing. That the paleontologists may have been at sea in regard to the exact determinations, and that the material is fragmentary and imperfect was as well known to me at the time of writing as to the paleontologist himself, but as the names are a matter of record I think I was justified in using them, no matter what becomes of them in the future, especially as Hatcher, Osborn and others have made important deductions from their occurrence. These remarks apply to the whole series of genera and species referred to by Dr. Matthew. It is rather interesting to have a vertebrate paleontologist make the statement that "correspondence in fauna is not conclusive evidence of identity in age," especially as it rather confirms the statement made by me in my article on the Judith River formation (*Journal of Geology*) wherein, in discussing the evidence of vertebrate fossils on the question of the age of the Judith formation, I say:

> Either the beds are identical in age or vertebrate paleontology has no place in stratigraphic geology and *non geologia sine paleontologia* becomes *non paleontologia sine geologia.*

The writer does not pretend to be a vertebrate paleontologist, nor is he able or willing to pass upon the value of the material studied by them, but he submits that he must be confined to what has been published by them, as

must all who use their material. It is impossible to go back of their record. As they (the vertebrate paleontologists), although fully aware of the fragmentary condition of the material they dealt with, gave not only generic but specific names and made certain deductions from their use, I do not quite understand why I was so sadly misled in using the names as I did, unless, as I said in my paper, vertebrate paleontology is of no use to the stratigraphic geologist. I wish to state here that I thoroughly believe in the value of the evidence of vertebrate paleontology.

While upon this subject, I wish to refer to another point, not, however, mentioned by Dr. Matthew. By some I have been criticized for not including in the lists of vertebrate fossils in my paper all that have been in any way referred to the Judith River formation, from all localities in Montana and in Canada, but it was my idea to limit the list to those found in the typical region of the Judith River formation, and on page 753 of my article on the "Stratigraphic Position and Age of the Judith River Formation" it is distinctly stated that Hatcher's list of Judith River vertebrates is used after the elimination of "all the species which are duplicated under other names" and also of all which come from beds not certainly of Judith age or that occur outside the typical area (the Judith Basin of Montana).

A. C. Peale

ICE CAVES

The contribution to *The Popular Science Monthly* for March on "The Sweden Valley Ice Mine," by Marlin O. Andrews, calls for some comment and criticism. In the first place it is calculated to convey the impression that such phenomena as he describes are exceedingly rare, whereas they are fairly common in middle latitudes—especially in limestone districts. In the second place the explanation given of such phenomena is faulty.

The writer of the above mentioned article appears to have come to his subject rather poorly equipped as regards geological knowledge, and though by his own statements supplied by the Federal Survey with information concerning the literature of the subject, to have availed himself very little of it. To begin with, his introduction detailing tradition as to presence in the region of silver mines known only to the Indians, in regard to the reliability of which he appears to have little doubt, does not serve to enhance our confidence in his ability to describe or explain geological phenomena.

Such traditions of "lost silver mines" prevail in nearly every community, but we hardly expect to find a man of science giving credence to them; especially if it is in a region where such mines are a geological impossibility. Potter County, Pa., is in such a region. It may be true that the county has never been covered by a detailed geological survey (a portion of it however has been covered by the Federal Survey and an account given of it in the Gaines Folio), but enough is known geologically of that portion of Pennsylvania to enable us to postulate the presence there of unaltered and little deformed sandstones and shales of Devonian and Carboniferous age, and to assert the entire absence from them of deposits in appreciable amounts of either lead or silver ores. Will the time never come when the diffusion of elemental geological knowledge is such as to render impossible the floating of such absurd "lost-silver-mine-known-only-to-the-Indian traditions"? Where did these Indians acquire their expert mineralogical and metallurgical knowledge that would enable them to detect silver in an ore or extract it therefrom? We know that when discovered by white men the American Indian was living in the "Stone Age" and utterly unacquainted with the extraction of metals from their ores.

When it comes to the account of the ice mine itself, the description in the article must be considered very inadequate from a geological point of view. Was the shaft sunk on undisturbed strata or on talus accumulation? If on the latter, we appear to have here a case of "talus ice accumulation," of which there are many instances. There is at least one other of these in Pennsylvania, if I remember cor-

rectly, either in Center or one of the adjoining counties.

The finding of "petrified wood" and "bones" possibly "human," in sinking the shaft, would seem to indicate talus deposits, but the "fern impressions" point to little shifted carboniferous strata.

Is the wood really "petrified," that is silicified, or does it consist of sandstone casts of same? If the latter, and in strata in place, it indicates carboniferous, and there could be no human bones associated with it. The reference to "loose shale, sharply inclined" up (?) the hill, might indicate overplacement due to creep. The nature of the strata (sandstone and shale) composing the Devonian and Carboniferous of that region would preclude the possibility of extensive underground channels or caverns, which require limestone and would consequently render very problematic the explanation proposed by Mr. Andrews for this Potter ice mine phenomenon.

If a seasonal reversal of underground air currents is to be invoked as an explanation, his diagrams introduced to illustrate this had better be inverted. Every "freezing cave" that has been represented in vertical section shows the more remote recesses of the cave lower than the mouth, and the more nearly vertical the circulation of the air is in consequence of this, the better the conditions for ice accumulation.

This may be illustrated by the conditions which prevail in a "freezing cave" near Gap Creek, Wayne Co., Ky., visited in August, 1898, by the author of this criticism. The cave is in the nature of a vertical sink, the opening of which is situated on the top of a Knob, called "mountain" in that section. The top is about 1,260 feet above sea level (220 above the drainage at the base). Descent into this cave was made by means of rough ladders. Various channels ramify from the main body of the sink, mainly downward. The "mountain" which consists of Mammoth Cave Limestone capped by a thin coping of Kaskaskia Sandstone, appears to be honeycombed with subterranean passages.

Into these passages the cold air tends to descend in winter and from them to rise in summer, due to changes in relative density conditions of the internal and external atmosphere. It appeared also to the writer (and this is the only contribution he wishes to offer to the explanation of ice caves) that the descent of the water through the underground passages during the winter, when this region has its abundant rains, would aid in the intake of cold air at the mouth of the sink somewhat after the manner of a Sprengle pump, and hence would contribute to the thorough refrigeration of the mountain or knob. This agency would operate with little force in summer, when the stage of cave waters is low.

We did not find that the inhabitants in the neighborhood of this Gap Creek ice cave attributed any of the accumulation of ice in it to the summer months, and while it is not impossible in accordance with the theory usually advocated for the explanation of such accumulation, that it might continue after freezing temperatures had disappeared on the outside, there is no indication that this condition of affairs has persisted into the summer, either in the case of this or of any other genuine "glaciere." The result of all actual investigation thus far is in support of this negative. Mr. Andrews fails to offer any first-hand observation in favor of his contention, for by his own statement his visit was made to the "ice mine" in the *spring*. His belief in *summer* accumulation still rests on hearsay evidence.

In view of the fact that such phenomena as we have been here discussing are by no means uncommon (Balch in his work, "Glacieres or Freezing Caverns," cited and quoted from by Mr. Andrews, lists some three hundred instances) it would appear that the subject is important enough to deserve treatment in our text-books on physical geography, where it would appropriately come up under the head of "caverns."

ARTHUR M. MILLER

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A HUMAN MONSTROSITY

On May 1, 1912, at Fayette, Missouri, was born a female child (colored) having two heads and three arms. The monstrosity was still-born, but had apparently completed its intra-uterine development. It weighed about fourteen pounds.

The legs are two in number, properly placed, and perfectly normal. The trunk as seen from without is fully developed. Posteriorly it is entirely normal, but the breadth increases considerably toward the anterior end. The chest region is at least one half again as broad as it should be. Other than is suggested by the breadth of the chest, however, there are no signs of duplicity in the trunk. The breasts are two in number and far separated, being normally placed with reference to the sides. The spinal column is single and central as far as can be determined without dissection.

Three arms are present. Two show no signs of irregularity either in position or structure. The third is somewhat dwarfed, and is located on a level with the two normal arms and midway between them. It extends upward and backward, and is attached to an irregularly developed scapula resting between the normal ones. The structure of this third arm and its hand is quite abnormal. Both upper and lower arm bones are present, but reduced in size. The wrist bones are not regular or at least do not permit of normal movement. The bones of the hand are not all present, there being only the metacarpals and phalanges of the thumb and first two fingers. The distal segment in each case bears a thickened claw-like nail.

The most striking feature of this monstrosity is its two heads. Each is set at a slight angle with the general axis of the body, and rests close beside, but not crowding, the other. As far as can be observed, there is no abnormality of any sort in connection with these heads except for the position.

There are many problems of scientific interest suggested by this specimen and no doubt many facts of interest and importance will be brought to light upon its dissection.

L. D. Peaslee

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THE OMAHA TRIBE

A review of "The Omaha Tribe," published in Science, June 13, 1913, calls for a few words from the authors, notwithstanding their disinclination to respond to a criticism which in some parts sounds more like vituperation. The opening sentences of the reviewer sound the keynote of his whole effort. He says:

> The most obvious thing about this monograph is the authors' well-nigh complete neglect of the work of their predecessors. It is their avowed purpose (p. 30) to borrow nothing from other observers and to present "only original material gathered directly from the native people." Apart from any consideration of historical justice this principle is unjustifiable from the standpoint of the student.

Now, the paragraph in the preface in the work from which the above is quoted, reads as follows:

> When these studies were begun nothing had been published on the Omaha tribe except short accounts by passing travelers or comments made by government officials. None of these writers had sought to penetrate below the external aspects of Indian life in search of the ideals or belief which animated the acts of the natives. In the account here offered nothing has been borrowed from other observers, only original material gathered directly from the native people has been used and the writer has striven to make, so far as possible, the Omaha his own interpreter.

By comparison of the two quotations it will be readily seen that the context has been willfully disjointed and that a segregated part of it was used as if it were the whole, an unjustified and unscholarly procedure.

The plan and purpose of the authors was to present the results of independent and original investigations on the Omaha, extending for over thirty years, and, as stated on p. 30, to avoid the criticism of other writers. The final adoption of this plan was due in a large degree to the regard which the authors felt for

the late Rev. J. O. Dorsey. They honored his personal character and his conscientious efforts, and preferred silence to the unwelcome task of pointing out the numerous errors throughout his work when he was no longer living to rectify them. Had Mr. Dorsey continued the study of the Omaha language and so perfected his knowledge of it he would have been better able to understand the meaning of the institutions and ideals of the tribe as they were explained to him in the native tongue. Regrettably his imperfect knowledge of the language, as can readily be seen in his Omaha texts, accounts for misconceptions that now appear in his writings.

It is with regret that the authors are now obliged to break the silence which they would have preferred to maintain. The misconceptions of Mr. Dorsey, cited by the reviewer, they corrected in the interest of truth, but without caring to detract from the credit due to the deserving author. Their competency to do so comes from the long and careful study of the tribal institutions and the beliefs on which they were founded, made in conjunction with practically all those men of the tribe who by position and ability were qualified to explain and to interpret tribal life and thought, and also to point out the differences between teachings that were to be taken literally and those which were symbolic in form and character.

The unusual advantages under which the monograph was prepared are indicated in the foreword (p. 30). One of the authors is not only himself an Omaha and well versed in his native language, but is equipped with a knowledge of English, so that niceties of the meaning and of the usage of words are made clear. In consequence of these facts and conditions it was in the power of the authors to state that among the Omaha tribe there was no belief that the ancestors of the people were animals and that at death men returned to the animals from which they sprang.

It would take too much space to reply to all the animadversions and innuendos of the would-be reviewer, nor would any good purpose thereby be served.

FRANCIS LA FLESCHE

SCIENTIFIC BOOKS

Éloges académiques et divers. Volume publié par le comité du jubilé scientifique de M. Gaston Darboux. By GASTON DARBOUX. Paris, A. Hermann & Fils. 1912. Pp. 525 + 4 + portrait. Price, 5 francs.

Jean Gaston Darboux, most eminent of living geometers, was born at Nîmes, France, April 13, 1842. His scientific career may be said to have begun with his entry into the École Normale Supérieure in 1861. To commemorate the fiftieth anniversary of this event[1] it was proposed early in 1911, by a large international group of his mathematical coworkers, friends and former pupils (Professor Hale, of Mount Wilson Observatory, and Professor Hancock, of Cincinnati, were the American representatives), to present to Professor Darboux a gold medal bearing his portrait, and an appropriate address signed by the participants. All mathematicians were invited to share in rendering this honor to Professor Darboux. The response was so generous, the committee was enabled not only to have the eminent artist M. Vernon execute the medal but also to publish a memorial volume. This volume contains a full report of the commemoration proceedings which took place at the Sorbonne, January 21, 1912; Lippmann, Appell, Poincaré, Picard, Volterra, were among the speakers. It also contains 6 éloges historiques (pages 1–306) which Darboux as secrétaire perpetuel delivered before the Academy of Sciences of the Institut after his election in 1900. And finally, we find a dozen of his miscellaneous addresses (pages 307–440) among which mention may be made of that on "The Unity of Science," delivered at St. Louis in 1904, and that on "Fulton and the Academy of Science," delivered in 1909.

The volume is of particular interest to the scientist because of the most attractive style

[1] Curiously enough the letter sent out by the international committee stated that the jubilee of service as a teacher in the system of public instruction in France was to be celebrated. This error is perpetuated on page 443 of the memorial volume to be presently referred to. As a matter of fact, Darboux is even now a year or so short of such a period of service.

of the éloges historiques here collected with annotations from volumes of the *Mémoires de l'Académie des Sciences de l'Institut de France*. Nowhere else are such extended accounts of the scientific careers of Bertrand (pages 1–60), Perrier (pages 61–115), Hermite (pages 116–172), D'Abbadie (pages 173–217), and Meusnier (pages 218–262) to be found.

Joseph Louis François Bertrand (1822–1900) was one of that remarkable group of mathematicians—among them, Poinsot, Poisson, Cauchy, Poncelet, Chasles, Lamé, Le Verrier, Liouville, Halphen, Hermite, Poincaré—who were, at least in part, the product of instruction at the École Polytechnique. A child prodigy and boy not to be bound down by the ordinary routine of the lycée he was nevertheless bachelier, licenciée and docteur ès science when 17 years of age—the youngest doctor of science whom France has ever produced. He then took the entrance examinations for the École Polytechnique. Bertrand has left us some details; Bourdon and Auguste Comte were the examiners:

> J'ai le souvenir de l'étonnement de M. Bourdon qui, sachant que j'étais docteur ès sciences, m'avait fait un examen difficile. A la suite de je ne sais quelle réponse, il me dit: "Vous n'avez donc jamais onvert une table de logarithmes?—Je lui répondis: Non, Monsieur, jamais." Il prit cela pour une impertinence; c'était la pure verité. Je n'avais fait aucun, devoir scientifique ou littéraire, jamais aucun calcul demandé par aucun maître.

Bertrand then continues:

> A l'École Polytechnique, j'étais un problème pour mes camarades. Reçu le premier et gardaut le premier rang dans toutes les épreuves, je les étonnais de temps en temps par une ignorance scandaleuse sur des notions qu'on enseigne en septième. Beaucoup d'entre eux croyaient à une ignorance affectée; j'en étais très haiteux au contraire. J'ignorais complètement, par example, quelle sorte de mots les grammairiens désignent par le terme d'adverbes.

Bertrand became "répétiteur adjoint d'analyse" at the École Polytechnique in 1844 and professor of analysis in 1856. This position he held till, by reason of the legal age limit, he was retired in 1895, after 51 years of service. On Bertrand, as well as on Poincaré in more recent times, was bestowed the supreme honor which France has in her gift for the élite of her scientists, namely, of election to both the Académie des Sciences (1856) and the Académie Français (1884) of the Institut.

For an account of Bertrand's researches in geometry, analysis, rational mechanics and physics, and of his text-books so popular in secondary education, reference must be made to Darboux's memoir. One may here also find a sketch of his family life and of his personal characteristics.

François Perrier (1833–1888), another graduate of the École Polytechnique, was employed for nearly a score of years by the general army staff, before he became a chief of the geodetic survey and professor of geodesy in the Ecole de Guerre, Paris. His extensive scientific work was in the field of geodesy.

Charles Hermite (1822–1901) at the time of his death was ranked first among French mathematicians. It was in connection with algebra and arithmetic that he was essentially inventor and creator; most notable were his contributions to elliptic and Abelian functions, algebraic forms and the theory of numbers. Through his proof of the transcendence of e he may well share with Lindemann (who employed very similar methods in discussing the transcendence of π) the honor of settling the problem of the squaring of the circle, which had been handed down through the centuries. All these topics and Hermite's career, as professor at the École Polytechnique and at the Sorbonne, as academician, as friend of mathematicians scattered all over the world—are treated at length by Darboux.[2]

Antoine Thompson d'Abbadie (1810–1897)

[2] Disciples of Francis Galton will surely find material of interest in studying hereditary traits of the families of some French mathematicians. For Bertrand was a nephew of Duhamel. Emile Picard and Paul Appell are nephews (the latter by marriage) of Bertrand. Pierre Boutroux is a nephew of Poincaré. Picard's wife was Hermite's daughter and Borel married a daughter of Appell.

was by birth an Irishman. His father, who was descended from an ancient French family, left his native land just before the Revolution and emigrated to Ireland, where he married a Miss Thompson. About 1820 they returned to France with their six children who had been born in Ireland. Two of the children, the brothers, Antoine and Arnaud, became scientists and performed much of their scientific exploration together in Abyssinia and Ethiopia. Antoine was chief of the Venus expedition to Hayti in 1882. Exploration, seismology, geodesy, meteorology, astronomy, claimed his attention at different periods of his life. His principal published work was the monumental "Geodésie de la haute Ethiope" (1873), which appeared shortly after his election to the Academy of Sciences.

General Jean Baptiste Marie Charles Meusnier de Laplace was born at Tours in 1754, and died at Mayence in 1793, as the result of wounds received in battle. Although thus cut off at the early age of 39 "il laissait" to quote the words of one of his friends, "des traces brillantes d'un intelligence d'élite secondée par un zèle infatigable."

His single memoir in pure mathematics was written just as he was leaving the École Polytechnique and contains a complete theory of the curvature of surfaces[3] from an entirely different point of view from that which Euler illuminated in 1763.[4] When Meusnier's memoir was presented to the Institut in 1776 it created a sensation (d'Alembert exclaimed, "Meusnier commence comme je finis"); and although only 22 years of age he was immediately elected a correspondent of the Academy of Sciences. While connected with the army during the next few years, Meusnier constructed a machine for the distillation of sea water and the extraordinary results, in connection with both the theory and practise of aerostation, which he presented to the Academy in 1784, brought about his election as academician.

It was in 1783 that Lavoisier and Laplace maintained before the Institut that the "element" water was formed by the combustion of hydrogen in oxygen. But some doubt existed as to the conclusions. This doubt was forever removed a year later, through experiment inspired by the genius of Meusnier. The subject was presented to the Academy in a "Mémoire . . . par MM. Meusnier et Lavoisier."

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[3] "Mémoire sur la courbune des Surfaces," *Savants étrangers*, t. X., 1785, pp. 477–510. It is this memoir which contains the famous theorem concerning the curvature of oblique sections of surfaces, with which Meusnier's name is always associated. English writers and the American historian Cajori incorrectly write Meusnier's name without the *s*.

[4] "Recherches sur la courbune des Surfaces," *Mémoires de l'Acad. d. sc. de Berlin*, [t. XVI.] (1760), 1767, pp. 119–143 + 2 Taf. A memoir with this title was presented to the academy by C. G. J. Jacobi on September 8, 1763.

Color Standards and Nomenclature. By ROBERT RIDGWAY, M.S., C.M.Z.S., etc.; Curator of the Division of Birds, U. S. National Museum. Pp. iii + 44, with 53 plates containing illustrations of 1,115 named colors, and providing a system of nomenclature permitting the definite location and designation of over 4,000 colors. Published by the author, Washington, D. C. Press work by A. Hoen & Co., Baltimore.

This work is a conspicuous example of that devotion to science which has led a few men to give the better part of their lives to the accomplishment of some important task, their hope of reward being little more than the satisfaction of having finished a work that will serve to advance science, and thus contribute to the welfare of mankind. More than twenty years ago the author began the attempt to supply a practical means of identifying the color of natural objects, so that this important property of these objects might be used with some degree of precision in identifying them. The task has been an enormous one, involving much pioneering in a little understood field of science. Many important problems had to be solved before the work

reached the final stages, and a vast amount of work had to be done over and over again as advances were made. The manner in which the more important of these problems have been met is set forth below.

This book is, of course, not the first attempt that has been made to supply standards of color. Ridgway himself had made an earlier attempt.[1] On this subject the author, in his preface, remarks: "Many works on the subject of color have been published, but most of them are purely technical, and pertain to the physics of color, the painter's needs, or to some particular art or industry alone, or in other ways are unsuited for the use of the zoologist, the botanist, the pathologist or the mineralogist; and the comparatively few works on color intended specially for naturalists have all failed to meet the requirements, either because of an insufficient number of color samples, lack of names or other means of easy identification or designation, or faulty selection and classification of the colors chosen for illustration."

The scheme of classification used is essentially that suggested by Professor J. H. Pillsbury.[2] The key to the arrangement of colors in this scheme is the solar spectrum, augmented by adding to the violet end of the spectrum the hues obtained by mixing violet and red in various proportions by means of the Maxwell color disks.[3]

In determining the number of color standards to be used the first problem was to determine the number of segments into which the original fundamental series should be broken. It is both impracticable and unnecessary to break this continuous series into the more than one thousand hues that are recognizably different to the normal eye. On the other hand, the number of segments must be sufficiently large that the gaps between them may be small enough to serve the practical purpose of identifying colors. On this point the author says: "Distinctions of hue appreciable to the normal eye are so very numerous that the criterion of convenience and practicability must determine the number of segments into which the ideal chromatic scale or circle[4] may be divided in order to best serve the purpose in view. Careful experiment seems to have demonstrated that thirty-six is the practicable limit,[5] and accordingly that number has been adopted."

As far as possible the gaps between each successive pair of these 36 elements of the fundamental series are in each case the same in amount of visual color difference. The scheme of nomenclature adopted provides for an additional color in each of these gaps, so that the fundamental series really consists of 72 named (or rather symbolized) colors, though only 36 are given on the color plates.

The fundamental series of colors thus obtained is modified in three different ways in order to cover the whole range of color variation. Each of these modifications produces a continuous series, which we may call a secondary series. Each of these secondary series begins with the fundamental series, either pure or as modified in a previous secondary

[1] "A Nomenclature of Colors for Naturalists," etc., 1886.

[2] See Science, June 9, 1893; also *Nature*, Vol. LII., No. 1347, August 22, 1895, pp. 390–402.

[3] If a wheel made up of sectors of different color be rapidly revolved on its axis the various colors will appear to blend into a single color. This is the principle of the Maxwell color disks. Throughout this review when reference is made to the mixing of colors what is meant is the blending of colors produced on a rapidly revolving Maxwell disk having its sectors differently colored. In this sense we may with propriety speak of the blending, say, of black and red as the mixing of these two colors, using the term color in its broadest sense. The mixing of pigments is a different thing, and is not here referred to.

[4] The addition of the hues obtained by various mixtures of violet and red renders the fundamental series a repeating one, and the various hues of which it is composed may hence be arranged in a circle in which there is at all points a gradual change of hue in passing from one primary spectrum color to another. (Footnote by the reviewer.)

[5] "That is to say, the practical limit for pictorial representation of the colors in their various modifications." (Footnote of the author.)

series, and ends with either white, black or neutral gray, according to the character of the modification under consideration. The nature of these secondary series will be understood from the details that follow.

Neutral gray is defined by the author as "being the gray resulting from mixture (on the color wheel) of the three primary colors (red 32, green 42, violet 26 per cent., which in relative darkness equals black 79.5, white 20.5 per cent.)." It may also be described roughly as follows: If by means of a white and a black disk on the color wheel a series of grays be prepared extending from white to black, the visual difference between each of the successive elements of the series being the same, the middle member of this series would be neutral gray. In other words, and roughly speaking, neutral gray is optically half way between white and black.[6]

The first of the three modifications of the fundamental series above mentioned consists of mixing the colors of the fundamental series with neutral gray. This produces a continuous series of "broken," or dull, colors. Since it is manifestly impossible to illustrate on the color plates every infinitesimal element of such a series, it becomes necessary to choose certain points in such series as standards. This choice is based on considerations similar to those involved in breaking up the original fundamental series into segments. Five different admixtures of neutral gray were used, giving five series of broken colors. The elements of the fundamental series are designated in the scheme of nomenclature adopted by the cardinal numerals from 1 to 72, only those designated by the odd numbers being illustrated on the color plates. The first series of broken colors, which are obtained from the fundamental series by the admixture of 32 per cent. of neutral gray, are designated by the primed numbers from 1′ to 71′. The second series of broken colors contain 58 per cent. of neutral gray, and are designated as 1″ to 71″. The third contains 77 per cent. of neutral gray, and are designated by the numbers 1‴ to 69‴. The fourth, 90 per cent., and designated as 1⁗ to 69⁗. The fifth, 95.5 per cent., designated as 1⁗′ to 67⁗′.

The fundamental series and the five series of broken colors are represented on the color plates by 150 color specimens. These are arranged in sequence, beginning with red of the fundamental series, and running through the spectrum six times. They form a horizontal line crossing each plate in the middle of the page, and constitute the middle elements of vertical series extending above and below them as follows:

Extending upward from each of these 150 color specimens is a series of "tints" of that particular color. These tints are obtained by mixing each of the 150 colors mentioned with white. Three tints of each color are shown, the first being obtained by mixing with the original colors of the series 9.5 per cent. of white, the second by the admixture of 22.5 and the third of 45 per cent. of white. Above the last tint in each vertical series is a specimen of white.

Extending downward from each of the 150 middle elements described above is a series of "shades" of these elements. The first of these shades is obtained in each case by the admixture of 45 per cent. of black with the original color of the middle series. The second shade contains 70.5 per cent. of black, and the third 87.5 per cent. At the bottom of each vertical column is a specimen of black. For each of the 150 elements obtained from the fundamental series and the five series of broken colors obtained directly from it by the admixture of neutral gray we therefore have a vertical series of shades and tints of that color. Each vertical series extends from white to black, the middle point being one of the 150 middle elements of the scheme of classification. This arrangement of the colors greatly facilitates the comparison of any object with the 1,115 color standards illustrated in the color plates with a view to determining and recording its color.

The system of nomenclature used by the author has already been partially detailed

[6] Some authorities use this term to mean gray of any shade or tint provided it shows no spectrum color.

above. It is the excellent system of identifying each color variation by means of symbols which serve to show the location of the color in the scheme of classification that is the most distinctive and original feature of the work. As stated above, each of the 36 segments of the fundamental series is designated by the odd numbers 1, 3, 5, etc., to 71, the even numbers being reserved for colors intermediate between them. These same numbers modified by the use of primes are used to designate the same colors modified by the admixture of neutral gray. Thus the color designated as 27''' is number 27 of the fundamental series weakened by the admixture of 77 per cent. of neutral gray (third series of broken colors).

The tints of any color are designated by the number of the color with the addition of one of the letters a, b, c, d, e, f or g. The three tints of each color illustrated on the plates are designated by the letters b, d and f, the other letters being reserved for tints intermediate between those of the specimens in the book. The shades of a color are similarly designated by the number followed by one of the letters h to n. Thus, 35'' i denotes the thirty-fifth segment of the fundamental series diluted as shown in the second series of broken colors, and further reduced by the admixture of 45 per cent. of black.

The system thus provides a means of designating not only each of the 1,115 specimens of color given in the plates, but all kinds of intermediates between them, the total exceeding 4,000 color variations. The magnitude of this task will be appreciated when it is remembered that in the author's previous book the number of colors named and illustrated was only 186, while in Milton Bradley's excellent little treatise on elementary color there are only 126.

The problem of choosing just what hues, tints, shades and broken colors should be represented in the color plates presents many practical difficulties. The simplest phase of this problem is that of choosing the particular spectrum hues to be designated by the simple names red, orange, yellow, green, blue and violet. The authorities are by no means agreed as to just what part of the spectrum is the reddest part of the red, the greenest part of the green, etc. Thus the red of ten different authors varies from 644 to 703 $\times$ 10^{-7} cm. in wave-length. Most of the other colors vary as much according to different authorities. Each author is a law unto himself in such matters. This is one of the reasons why any system of color standards which will serve the main purpose of such standards, namely, that of identifying the actual colors met with in nature and in the arts, would be eagerly adopted by naturalists, as well as by those who find need of color standards in the arts.

A much more important difficulty arises from the fact that certain hues of the fundamental series require more elements than others in the series of tones between white and black in order to make the optical intervals between the tones chosen as standards equal in the different series of tones. The author has chosen to represent three tints and three shades of each of the pure colors. This gives a series of seven elements in each series of tones. Except in the yellows this seems to be very satisfactory, but the eye can distinguish such small differences of tone in this part of the spectrum that a larger number of elements in the series of tones would have been helpful. In the yellows and greens there is also a considerable optical interval between the darkest shade (containing 95.5 per cent. of black) and the adjacent samples of black.

The fact that in the series of broken colors the optical intervals between the adjacent hues are less evident than in the full colors also gives rise to a number of practical difficulties in determining just what elements to drop out in order to make the intervals of suitable magnitude and still cover the range of color variation in a satisfactory manner. None are omitted in the first and second series of broken colors, but in the third and fourth each alternate hue is omitted, while the fifth series contains only the six hues ordinarily designated as the primary spectrum colors, except that yellow-orange replaces orange as

being more nearly intermediate between red and yellow.

The last of the 53 color plates gives two series of tones of gray, one obtained by mixing white and black on the color wheel, the other by mixing lamp black and Chinese white. Plates XXII. and XXIV. are extras, from one of several series made during the progress of the work, given because they show a number of important intermediates of the present series that are very useful. Both these plates fall in the first series of broken colors.

Every one of the 1,115 specimens of color shown on the plates is given a name. The method used in selecting these names is given in considerable detail. An excellent index of color names is given on pages 29 to 40, with references to the corresponding specimens in the plates.

Not the least valuable feature of the book is the list of definitions of color terms on pages 15 to 20. The list of dyes and pigments used in the preparation of the Maxwell disks representing the 36 colors of the fundamental series is given on pages 26 and 27. The text ends with a list of a few of the modern books on the subject which the author found most useful in his work.

It is perhaps too much to say that this monumental work is the final solution of the problem of color standards, but it is doubtful if any one so competent as Ridgway in matters relating to color will in the near future devote a very important portion of his working life to the subject as Ridgway has done. He has certainly produced a *usable* set of standards.

W. J. SPILLMAN
U. S. DEPARTMENT OF AGRICULTURE

Microbes and Toxins. By E. BURNET. Translated by C. BROQUET and W. M. SCOTT. G. P. Putnam's Sons. 1912.

When Professor Metchnikoff was asked by the publishers of the Bibliothèque de Philosophie Scientifique to prepare for that library a book on microbes and toxins he turned the task over to one of his younger colleagues, Dr. Etienne Burnet. An English translation has promptly been prepared and makes a volume of some 300 pages. There are four introductory chapters—on the carbon and nitrogen cycles, on the presence of microbes on the surfaces of the human body, on the morphology, and on the physiology of the microbes—and a concluding chapter on chemical remedies for microbic disease (sleeping sickness and syphilis). The other ten chapters forming the bulk of the book deal directly with the problems of infection and immunity.

The book is a little difficult to place. According to Professor Metchnikoff's preface it appears to be intended for general reading. "It is time," he says "for bacteriological science to leave the laboratory and the lecture theater and to take its place before the great public, in order that its benefits may receive the widest and readiest application." It takes a mature mind and a special gift, however, to produce a really popular and yet valuable book upon a technical subject. The present volume is crammed with minute details and discussion of controversial points and seems to the reviewer quite unsuited for the general public. Even for a student's text-book, there is more detail than is desirable. On the other hand, the treatment is by no means sufficiently full and complete to serve as a reliable work of reference for the advanced worker.

Its greatest value perhaps lies in the fact that it presents very fairly the position of the Pasteur Institute headed by Professor Metchnikoff; and the important part played by this school in the development of our knowledge of immunity makes such a "brief," if it may be called so, a valuable contribution to the history of bacteriology. The problems of intestinal bacteriotherapy in Chapter II., of phagocytosis in Chapters VI. and X., and of the mechanism of immunity in Chapter XI., for example, are of special interest.

The view is of course always that of Professor Metchnikoff and his associates rather than a well-rounded presentation of generally accepted opinion; and doubtful points are often dismissed with what one is tempted to

characterize as truly Gallic dogmatism. In regard to the relative importance of humoral and phagocytic factors in immunity statements of the most sweeping nature are made. So we read on page 205: "Are the opsonins substances or properties new and unknown before Wright's researches? Numerous experiments ascribe to the opsonins of normal serum the same properties as characterize the complement. They are products of the leucocytes." And again on page 227: "There are only two 'theories,' that of Ehrlich and that of Bordet, which, with their conjectures, their uncertainty, their attempts at explanation, and their continual state of incompleteness, are striving to round off the positive doctrine, the expression of undoubted facts, namely, phagocytosis." "It is no way of recognizing the capital importance of phagocytosis to admit that anti bodies and other humoral properties are produced by the phagocytes. The essential fact is the destruction of the microbes by incorporation and digestion. Extraphagocytic destruction is so much an exceptional case that it can not even be brought in as opposition."

The illustrations are for the most part crude line drawings of the type found only in French texts. The English translation is somewhat unfortunate, abounding in constructions like the following (from p. 171): "To prepare an anti-endotoxin, as in the preparation of an antitoxin, it is necessary to inject several times into an animal, for example, the horse, the toxic substance, in this case the bacterial bodies, entire or broken up"; so that the reader is almost reminded of the fate of the famous jumping frog after his translation into French and back again.

C.-E. A. Winslow

SPECIAL ARTICLES

A THIRD GROUP OF LINKED GENES IN DROSOPHILA AMPELOPHILA

The existence of a group of sex-linked genes in *Drosophila ampelophila* which are linked to each other in different degrees has been demonstrated by Morgan in numerous papers ('10, '11, '12) and by Sturtevant ('13). The fact that the black and vestigial factors, which are not sex-linked, are linked to each other, was reported by Morgan and Lynch ('12) and by Morgan ('12), and these genes were considered as lying in the "second chromosome." The present paper presents evidence showing the existence of still another group of genes, which are located in the "third chromosome."

The pink-eyed fly, first described by Morgan ('11), has been shown (Morgan, '11, '12) to behave as an ordinary Mendelian recessive to the normal red. That this factor is independent of those in the second chromosome is shown by the following experiments:

Red black ♀ × Pink gray ♂	→ red gray ♂ and ♀ →	red gray	113
		red black	52
		pink gray	47
		pink black	22
Red gray ♀ × Pink black ♂	→ red gray ♂ and ♀ →	red gray	279
		red black	96
		pink gray	107
		pink black	40
F_1 red gray ♀ from above × Pink black ♂	→	red gray	96
		red black	111
		pink gray	67
		pink black	77
Vestigial red ♀ × Long pink ♂	→ long red ♂ and ♀ →	long red	717
		long pink	268
		vestigial red	136
		vestigial pink	50

Except for disturbances due to differences in viability these are obviously 9:3:3:1 ratios, except the third, which is 1:1:1:1, as expected. Evidently pink is not linked either to black or to vestigial.

In the balloon-winged stock (see Morgan, '11) there appeared a very dark mutant, which has been named ebony. This fly is darker and more shiny than the black fly, and has a slightly greenish, smoky color when young. It behaves as a simple Mendelian recessive to the normal gray color, though the heterozygous form is often somewhat darker than the wild fly. The females of this race are often sterile, and seldom produce many offspring, but the males breed freely when mated with other females, and produce many offspring. That the gene concerned is not in the second chromosome is indicated by the following experiment:

Vestigial gray ♀ × Long ebony ♂ → long gray ♂ and ♀

long gray	268
long ebony	79
vestigial gray	94
vestigial ebony	24

This is a simple 9:3:3:1 ratio, except that the viability of the ebonies is not quite as good as that of the grays. Ebony has also been shown to be independent of two other wing factors in the second chromosome—curved and balloon.

When pink-eyed flies were crossed to those with ebony body color, the following result was obtained:

Gray pink × Ebony red → gray red

gray red	3764
gray pink	1369
ebony red	1112
ebony pink	0

This count includes a few F_2 flies derived from F_2 red grays mated together, but also includes large numbers of F_2's from each of the reciprocal crosses—ebony ♀ × pink ♂ and pink ♀ × ebony ♂. In the later generations from these crosses the writer was able to obtain a few ebony pink flies, and a pure stock of this combination was then made up. When these flies were used for "coupling" experiments the result was as follows:

Ebony pink × Gray red → gray red

gray red	272
gray pink	12
ebony red	10
ebony pink	65

The result indicates that the two genes involved are really linked in the ordinary sense. In order to get more exact data doubly heterozygous flies have been crossed to double recessives (ebony pink). Owing to the difficulty of breeding ebony females it has not yet been possible to make any extensive tests of the amount of crossing over in males, but the 88 flies so far raised from doubly heterozygous males by ebony pink females have none of them been cross-overs. Similar tests of doubly heterozygous females have disclosed the existence of much variability in the amount of crossing over, the extreme values so far obtained being about 1 per cent., on the one hand, and about 27 per cent., on the other. This matter is being further investigated, and it seems probable, from results already obtained, that external conditions play a large part in it. The detailed counts are reserved until this side of the question is more thoroughly worked out, but the totals are given below, because they show beyond question that linkage occurs. When females that showed "coupling" (in Bateson's ('06) sense) —*i. e.*, in which red and gray, pink and ebony were linked—were tested by mating to ebony pink males, the result was as follows:

Gray red (heterozygous) ♀ × Ebony pink ♂

gray red	880
gray pink	86
ebony red	65
ebony pink	691

Tests of females showing Batesonian "repulsion" (having red linked with ebony, pink with gray—Bateson and Punnett, '11) gave the following result:

Gray red (heterozygous) ♀ →	gray red	3
	gray pink	601
×	ebony red	584
Ebony pink ♂ →	ebony pink	4

This gives a total of 158 cross-overs out of 2,914 flies, but the absolute proportion is not very significant, because of the variability mentioned above. That rather strong linkage exists, however, there can be no doubt.

A. H. Sturtevant

Columbia University,
May, 1913

THE NORTH CAROLINA ACADEMY OF SCIENCE

The twelfth annual meeting of the North Carolina Academy of Science was held in the Science Building at the State Normal College, Greensboro, on Friday and Saturday, April 25 and 26, 1913.

Following a meeting of the executive committee early on Friday afternoon, a session was held for the reading of papers. At the night meeting, after an address of welcome by President J. I. Foust, of the college, President C. S. Brimley, of the academy, delivered his presidential address on "Zoo-geography." Adjournment was then had to the Students' Building, where the members of the academy were given a reception by the faculty of the college.

On Saturday morning the academy met for its annual business meeting. Reports were then made by the secretary-treasurer and the several stated committees. Twelve new members were elected. The finances were shown to be in good shape—all bills being paid, with $125 in the savings bank. It was noted that Dr. C. W. Stiles, one of our members, had by action of the executive committee been appointed to represent the academy at the Ninth International Zoological Congress at Monaco, March 25–29, 1913.

The following officers were elected for the ensuing year:

President—Franklin Sherman, state entomologist, Raleigh.

Vice-president—Z. P. Metcalf, professor of entomology, North Carolina Agricultural and Mechanical College, West Raleigh.

Secretary-treasurer—E. W. Gudger, professor of biology, State Normal College, Greensboro.

Additional Members of Executive Committee—W. C. Coker, professor of botany, University of North Carolina, Chapel Hill; J. J. Wolfe, professor of biology, Trinity College, Durham; C. S. Brimley, naturalist, Raleigh.

Following the business meeting, the reading of papers was resumed and continued until the program was finished and adjournment had at 1:15 P.M. The attendance was 27 out of a membership of 76. There were 22 papers on the program. Four of these were read by title, one was presented by another member in the absence of the author, and the other 17 were read by their authors in order as called for on the program.

The papers read were as follows:

Zoo-geography: C. S. Brimley, Raleigh.

Briefly discusses the primary life areas of the world, which the author believes to be five in number, namely, an Australian, a Neotropical, an Ethiopian, an Indian with the limits usually assigned to them by zoologists, and lastly a Northern Realm, including all of the earth's land surface lying north of the other four. The paper then divides the Northern Realm into three regions, an Arctic, a Eurasian and a North American, and proceeds to divide the North American continent into the usual seven life zones, Arctic, Hudsonian, Canadian, Alleghanian, Upper Austral, Lower Austral and Tropical. The life zones entering the state of North Carolina are then discussed at greater length and found to be four in number, the Canadian, Alleghanian, Upper and Lower Austral. The first is stated to occupy the summits of the mountains above about 4,500 feet, the second that portion of the mountain region lying between 2,500 and 4,500 feet elevation, the third comprising the mountain valleys under 2,500 feet, and the central part of the state lying between the mountains and a line drawn from Weldon to Raleigh, and thence to Charlotte, the fourth including the remainder of the state, namely, all lying south and east of the above-named line. The animals distinctive of these zones are named and certain irregularities and anomalies in distribution are pointed out.

This paper will appear in full in the May issue of the *Journal of the Elisha Mitchell Scientific Society.*

Will Cells of the Embryo Sea Urchin, when Reintroduced into the Body of the Adult, become Tissue Cells of the Latter? H. V. Wilson, University of North Carolina, Chapel Hill.

Plasmodia formed by union of lymph cells were allowed to engulf blastulæ, and were grafted on the wound membranes which close in apertures

made in the test of the urchin. The blastulæ after certain changes broke up into their constituent cells. In this way dissociated embryonic cells were brought into the midst of a developing membrane, having a very simple histological character. In the actual experiments a very large proportion of the embryonic cells underwent degeneration. There was some evidence, though by no means convincing, that groups of the smaller cells became part of the developing membrane.

Alternation of Generations in Padina: JAS. J. WOLFE, Trinity College, Durham.

While at work on the life history of *Padina* at the Fisheries Laboratory at Beaufort it seemed worth while to test the theory of alternation of generations in such plants by the cultural methods devised by Hoyt.[1] Numerous cultures were made during the summer of 1910 and the next—all having but indifferent success. They were repeated in 1912 with somewhat better results. The cultures of tetraspores produced a total of 134 male, 154 female, and no tetrasporic plants. Those from fertilized eggs were somewhat less conclusive. Nevertheless, the evidence from cultures strongly supports the view that in *Padina* there is a real alternation of sporophyte with gametophyte.

Gestation in the Nurse Shark, Ginglymostoma cirratum: E. W. GUDGER, State Normal College, Greensboro, N. C.

A brief description was given of the breeding habits and of some points in the embryology of this shark, which was studied at the laboratory of the Carnegie Institution at Tortugas, Florida, in June and July, 1912. A brief account has been published in the Year Book for 1912 of the Carnegie Institution of Washington, Department of Marine Biology, pages 148–150.

Hybridization Experiments on Frogs: W. C. GEORGE, University of North Carolina, Chapel Hill.

Chorophilus n. feriarum was crossed with *Acris gryllus.* About half of the eggs segmented. (In the pure *Chorophilus* control practically all the eggs segmented.) The development was markedly retarded and was abnormal. The conspicuous abnormalities concerned the behavior of the yolk pole. Thus segmentation at this pole was not perfect, and the closure of the blastopore was interfered with in such wise that there developed the well-known abnormal type produced in so many ways, characterized by a large blastopore area and the differentiation of the neural plate.

[1] *Bot. Gaz.,* January, 1910.

The Toxicity of Cottonseed Meal: W. A. WITHERS, J. F. BREWSTER, L. F. WILLIAMS and J. W. NOWELL. With the collaboration of R. S. CURTIS and G. A. ROBERTS, North Carolina Experiment Station, West Raleigh.

The authors conclude from experiments, some of which have been published,[1] that the toxicity of cottonseed meal is due to a constituent group of the proteins, probably one containing loosely bound sulphur. They suggest some form of iron as an antidote, having found with Belgian hares that citrate of iron and ammonia (0.7 gm. daily) is effective in overcoming and in preventing cottonseed meal intoxication. Further experiments are in progress with small animals and with swine. Efforts to isolate the toxic substance will be continued.

Fishing for Sharks in Key West Harbor: E. W. GUDGER, State Normal College, Greensboro.

In this paper the capture was described of a 7-foot 10-inch male specimen of *Hypoprion brevirostris* and a 10-foot 10-inch female specimen of the tiger shark, *Galeocerdo tigrinus,* in Key West Harbor, in July, 1912. These two fishes not being very well known, it is proposed later to publish careful descriptions with exact measurements.

The jaws of the tiger shark, which were exhibited, measured 1 foot 4 inches straight across, and around the curve of the jaws 1 foot 9 inches. Its stomach contained more than a half barrel of miscellaneous material, including a cow's head (dehorned) minus the lower jaws, the vertebral column of a sheep, the scutes of a green turtle, the bones and feathers of two birds and a lot of tin cans and sea weed. The uteri were dissected, but unfortunately the fish was not in breeding condition.

A Second Capture of the Whale Shark, Rhineodon typus, in Florida Waters: E. W. GUDGER, State Normal College, Greensboro.

This paper will be published in full in SCIENCE.

For the following papers no abstracts have been received:

"Some Possible Effects of Solar Rays," George W. Lay, St. Mary's School, Raleigh. (Read by title.)

"Seasonal Periodicity in the Water Moulds," W. C. Coker, University of North Carolina, Chapel Hill.

[1] *Proceedings Society for Promotion Agricultural Science,* 1912, pp. 19–21, and *Journal of Biological Chemistry,* Volume XIV. (1913), pp. 53–58.

"Vaccination against Tuberculosis," C. A. Julian, Thomasville.

"The Geological History of Western North Carolina," J. H. Pratt, State Geological Survey, Chapel Hill.

"Action of Ammonia upon Arsenic Iodide," C. H. Herty and J. T. Dobbins, University of North Carolina, Chapel Hill.

"A List of the Known Homoptera in North Carolina," Z. P. Metcalf, Agricultural and Mechanical College, West Raleigh.

"The Chestnut Bark Disease," S. C. Bruner, Agricultural and Mechanical College, West Raleigh.

"Serum-simultaneous Method of Immunizing Hogs against Cholera," W. C. Chrisman, State Department of Agriculture, Raleigh.

"Behavior of the Spermatozoa of the Crab," Raymond Binford, Guilford College.

"The Granville Tobacco Wilt Problem," H. R. Fulton, Agricultural and Mechanical College, West Raleigh. (Read by S. C. Bruner.)

"The Swamp Lands of Eastern North Carolina," J. H. Pratt, State Geological Survey, Chapel Hill.

"The Influence of Environment on Reproductive Processes," W. C. Coker, University of North Carolina, Chapel Hill.

"Survivals and Adaptations along the South Atlantic Coast: A Study in Anthropogeography," Collier Cobb, University of North Carolina, Chapel Hill. (Read by title.)

"A New Interference Apparatus" (with a demonstration), C. W. Edwards, Trinity College, Durham.

"The Closing Up of Lake Basins in Massachusetts, Michigan and North Carolina," Collier Cobb, University of North Carolina. (Read by title.)

E. W. Gudger,
Secretary

State Normal College,
Greensboro, N. C.

Societies and Academies

The Academy of Science of St. Louis

At the meeting of the academy on March 3, Dr. R. J. Terry, of the Washington University Medical School, read his second paper on "The Development of the Cranium in Mammals."

Dr. Terry stated that Weiss's study of the occipital region of embryos of white rats revealed the fact that the dens epistrophei in these animals is composed of two elements, the one generally recognized as comparable with a centrum for the atlas, the other lying cephalad of this and forming the extremity of the dens. The latter is derived by independent chondrification in the tissue about the notochord cephalad of the atlas and where the former crosses the dorsal surface of the basal plate of the cranium. Weiss regarded this cephalic element as representing the centrum of an occipital vertebra or a proatlas.

The presence of an element in the dens epistrophei of cat embryos has been observed developing cephalad of the component identified as the centrum of the atlas and extending upon the basal plate of the cranium. This component is derived from the mesenchyma which, in the form of a cone traversed by the notochord, extends from the level of the atlas cephalad upon the basal plate and there lies in a deep median groove. Chondrification in this part of the dens occurs later than in that part related to the atlas, but the two processes appear not to be entirely distinct.

At the meeting of April 21 Professor R. A. Hall, of Washington University, stated to the academy that he had succeeded in preparing neutral tri-ammonium citrate in commercial quantities.

Professor Hall described a method in which neutral tri-ammonium citrate was prepared by passing an excess of dry ammonia gas into a well-cooled solution of the water-free citric acid in an anhydrous solvent.[1] The yield is quantitative. Tri-ammonium citrate thus prepared is a stable, white crystalline substance, not hygroscopic and not affected by the CO_2 of the atmosphere. It dissolves readily in water and the freshly-prepared solution is neutral to sensitive litmus, azolitmin, corallin, methyl red, etc. Rigorous analyses of both the ammonia and the citrate content of the salt show it to be the tri-ammonium citrate. Further investigation of its physical-chemical properties is being made.

As the method of preparation is simple and inexpensive and the yield good, it is evident that this means a solution of the difficult problem of the fertilizer chemist in the preparation of neutral ammonium citrate solution for the determination of the insoluble phosphoric acid in fertilizer analysis.

G. O. James,
Corresponding Secretary

[1] This body was first prepared by this method two years ago at the time of the investigation of the conductivity method of preparing neutral ammonium citrate solutions, but a press of other research prevented its analysis and complete identification until the present time.

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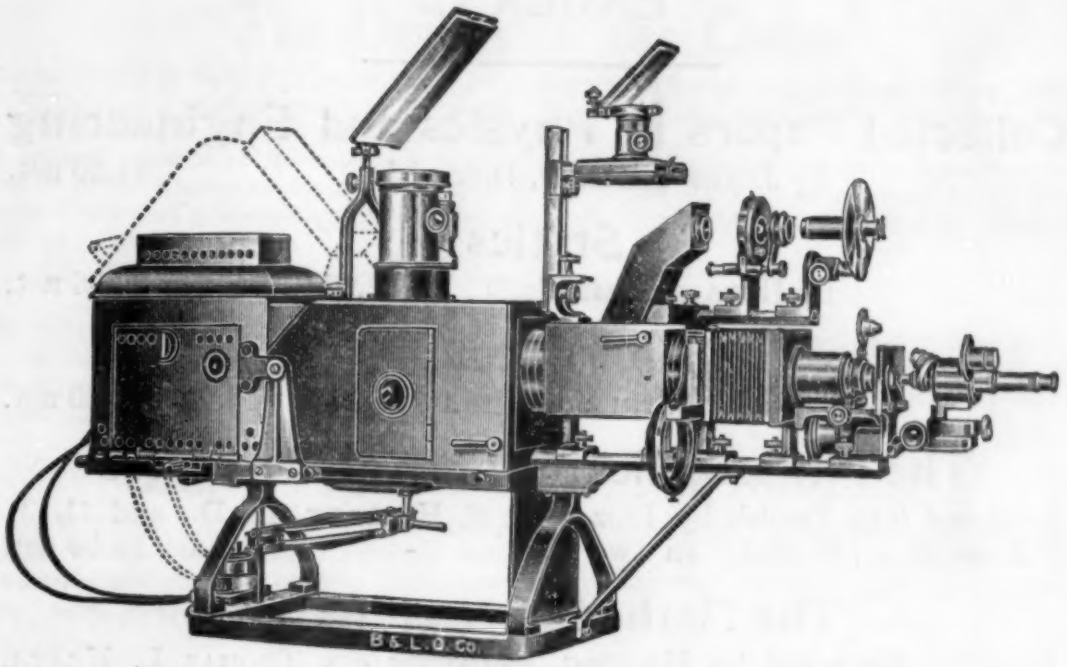

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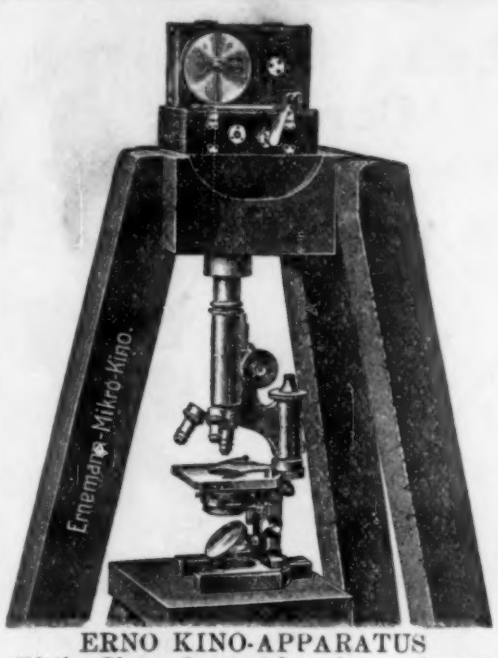

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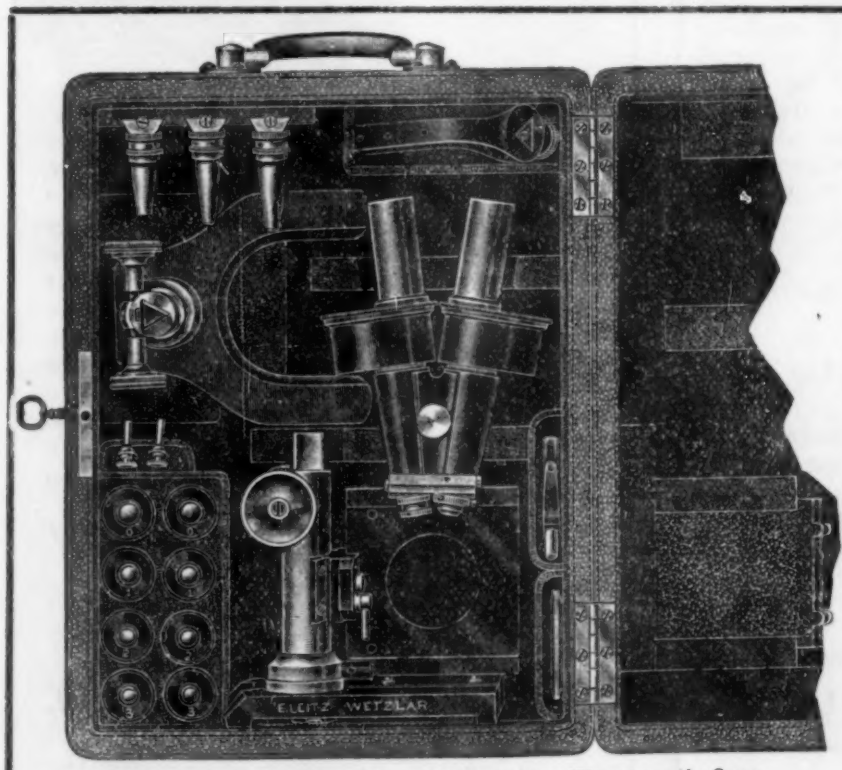

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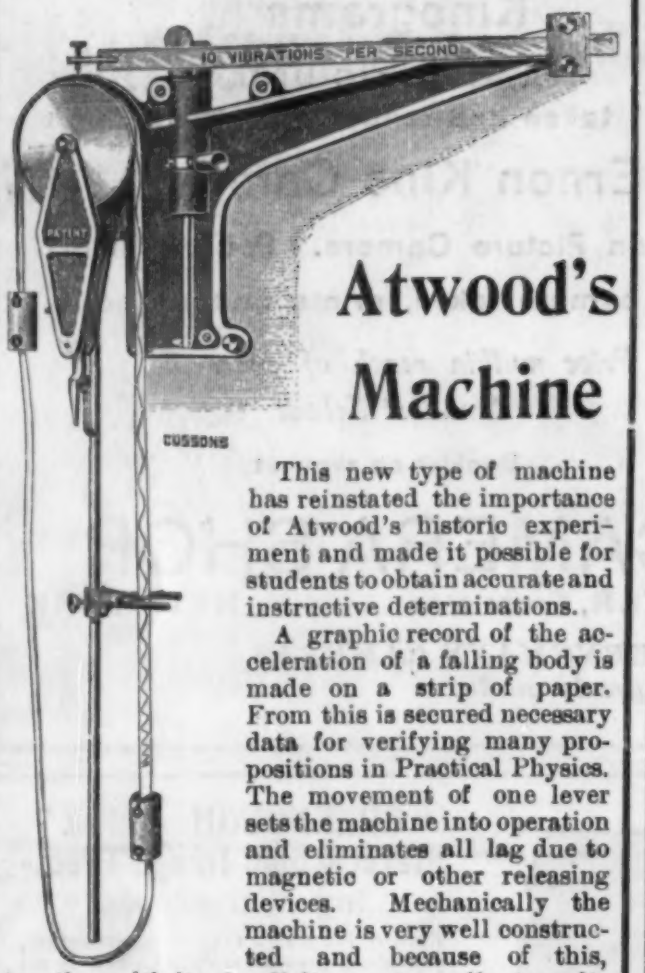

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